



Risk assessment and prevention of occupational accidents

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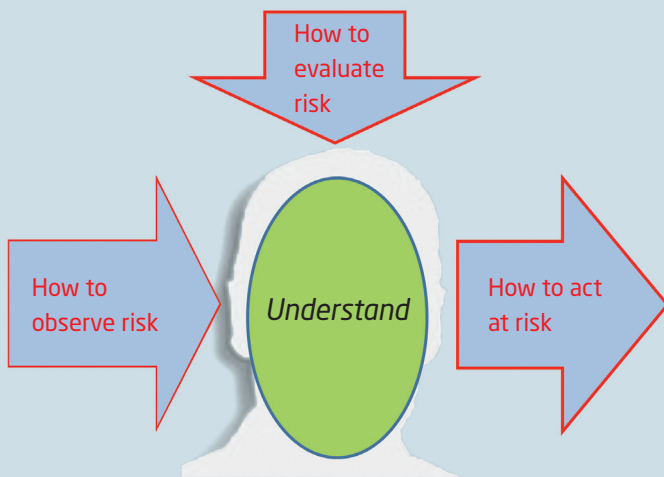
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Risk assessment and prevention of occupational accidents

Report 4.2010

DTU Management Engineering



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February 2010

Preface

WORM stands for “Working group for Occupational Risk Model”, which is a large project that was conducted in The Netherlands between 2003 and 2008 and financed by the Dutch Ministry of Social Affairs and Employment.

Dan-Worm is the term used for the Danish version of WORM.

This report describes the results of the Dan-Worm project, the goal of which was to give Danish companies the opportunity to use the results from the Dutch project. An additional intention of the DanWorm project was to attempt to simplify the results from WORM in such a way to allow knowledge and tools to be implemented into small and medium-size companies.

The report contains a thorough introduction to the theory of accident prevention, a description of the Dutch WORM project and the tools that have been developed in the Dan-WORM project. The report presents proposed applications of the tools and prevention processes.

The Dan-WORM project is being financed by the Working Environment Research Fund (Arbejdsmiljøforskningsfonden) and has also been included in the Centre for Research in Production, Management and the Working Environment in Small Enterprises (Center for forskning i produktion, ledelse og arbejdsmiljø i mindre Virksomheder) “DAVID”, for which the National Research Centre for the Working Environment (Det Nationale Forskningscenter for Arbejdsmiljø), NFA, has been responsible.

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Kemi Risk aps

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Introduction

In 2004 a major project was initiated in The Netherlands to chart the risks of occupational injuries and identify the safety measures (safety barriers) that can prevent injuries. This consisted of the in-depth analysis of 9,000 serious occupational accidents and those requiring hospitalisation in depth based on the studies conducted by the Dutch working environment authority for such cases. In order to be able to calculate the probability of the risk of injury the exposure time has also been charted, i.e. by means of surveys investigated how many people are exposed to different types of risk and the extent to which the requisite safety barriers are in place and the conditions of these barriers (RAM 2008).

On the basis of these analyses and survey data an electronic program, ORM (Occupational Risk Model) has been developed that enables the risk of an occupational accident for a specific job to be calculated by stating your work tasks and how these tasks are performed. Using the information that is entered and the information contained within the program, provides an indication of the types of injury that you are at greatest risk of and the type of prevention that is the most effective both in terms of the working environment and cost.

The problem with this program is that a fairly large quantity of information is required before you can calculate the probability of injury. Not least, a magnitude of information is involved that small enterprises would probably never have the resources available to collect. The program is therefore of little interest to these enterprises.

One of the goals of the DanWorm project is to secure a Danish version of the Dutch ORM program in the form of a Danish translation. Another goal is to investigate and develop a version of ORM that can be more easily accessed by small enterprises in particular. A final goal of the DanWorm project is to investigate whether on the basis of data from both the Dutch and Danish project it is possible to develop a targeted auditing system for small enterprises.

This report has the following content:

Chapter 1 contains the most important conclusions that have resulted from DanWorm. This conclusion section goes across the chapters of the report with the aim of highlighting the messages of and the relationships between the chapters of the report. This provides us with a general overview of the content of the report and of the primary results.

Chapter 2 contains the theoretical basis for the research project including an understanding of the prevention of occupational accidents, an understanding of the significance of management in prevention, an understanding of the barrier concept and finally an understanding of the small enterprise and its ability and opportunities to act proactively in relation to occupational accidents.

Chapter 3 contains a description of the Dutch development project on which the present project is based and in which it has a stake. There is also a presentation of the methodology development and the results from the work in The Netherlands.

Chapter 4 contains a presentation of the Danish research project, DanWorm, including methodology, processes and development elements.

Chapter 5 contains a presentation of the results from DanWorm and the various tools that were developed during the project as well as their general application.

Chapter 6 places these results and tools within the framework of the preventative arrangements within a company and the application of APV and audits. An attempt is made to illustrate the simple method for the small enterprise.

In addition, comprehensive supplementary material has been produced, which includes:

- A. 17 INFO chart on accident risks
- B. A list of 64 hazards with indications of safety barriers and quality parameters
- C. A presentation of exposure data within industries and trade groups for 64 hazards
- D. DanWorm data material for the enterprises in the data collection and data for carpenters and caretakers and their exposure files

The main report, the supplementary report and programs to be used for data collection have been published on a CD ROM.

Chapter 1. Conclusions from the project

Everybody would naturally prefer to avoid occupational accidents, both for ourselves, for our acquaintances, for our co-workers, etc. The question is whether we are prepared to invest the energy that is required and to have the focus to avoid injuries when none have occurred for some time.

With accidents you do not know what should have been done until after the accident has taken place, by which time it is too late. This is why we study accidents in order to understand and learn, but usually without this learning being passed onto others. We often take the blame and believe that we have done something wrong, which is of course not much use to others.

Many accidents are just put down to being something that just happens. They are viewed as being fortuitous events, unless we are talking about major catastrophes for which somebody has to take the blame.

Finally, if an accident becomes the subject of a closer investigation, this is usually done for the purpose of establishing liability and a liability to pay damages and very rarely to chart the fundamental causes.

The following metaphor can be used:

"An accident occurs more or less as randomly as a lightning strike. We are fully aware of the conditions that form the basis for lightning and also the conditions that cause it to strike where it does, but we never know when and where it will occur... It is the same with accidents. However, there is the problem when accidents are investigated that we often only investigate "the place where the lightning struck" and rarely the conditions that formed the basis for the "occurrence of the lightning", i.e. the underlying causes."

When we discover that the immediate causes are perfectly normal everyday conditions that do not usually give rise to an accident, we do nothing and are happy to say to those affected

Be more careful next time – watch out – let it be

This chapter will suggest alternative courses of action. The chapter is a summary of the report and includes the five most important suggestions that have been drawn on from across the other chapters of the report.

1.1 Learning from the large number of accidents

1.1.1 The message

Each individual accident will always be unique. Only when the large number of accidents and their underlying causes have been analysed will the risks over which it is vital to gain control and the measures that should be implemented be identified.

This is not to say that we should not investigate individual accidents in order to learn from them, but rather that the knowledge that is gained from individual accidents is limited and we must never construe it so that if we ensure that this accident does not happen again, we would have done all that we could to prevent other accidents.

1.1.2 Background

The investigation of occupational accidents is an investigation into what occurred by looking back and attempting to reconstruct the course of events. There is always a charting of what we know occurred and with the benefit of hindsight stated what went wrong, cf. Chapter 2.

In the vast majority of cases it is easy to see when the injured party could have done differently in the situation and thereby have avoided the accident. We therefore talk about human behaviour as being the factor that triggers the accident.

However, from a more detailed analysis of very commonplace accidents it also emerges that there will be a large number of other factors of significance to the situation with which the injured party is faced and which influence his or her behaviour.

It also emerges that it is the simultaneity of different factors that causes the accident rather than individual causes.

It is the simultaneity of there being a person on a scaffold that has a faulty guard rail and the person trips over a board, loses balance and consequently falls from the scaffold.

It is the simultaneity of a saucepan standing on the floor, the contents of the saucepan being very hot and the saucepan standing in the way of a trainee chef who is so busy the he does not see the saucepan and consequently steps on the saucepan and burns his foot.

It is the simultaneity of a person who is descending from a ladder whilst carrying a heavy load with both hands, who does not see where he is putting his feet and is unable to break his fall if he were to stumble and is also rushing as he is pressed for time who consequently stumbles, falls down and breaks his leg.

In all of these situations an accident would not have occurred if all of the causes were not present. This has two significances.

1. The person believes that there is no risk when he is in similar situations, and where only some of the causes are present that nothing will happen and therefore believes that he can cope with the situation, and.
2. That it is difficult for the person to perceive “simultaneities” that can arise in actual situations. Vigilance and very quick reactions are required as these can arise spontaneously and instantaneously. Furthermore, the combination of simultaneities is manifold and requires considerable experience and insight.

However, in a large number of situations people are able to look after their own safety, they see the risk factors and take the necessary precautions.

It is therefore when a person is not fully prepared for the situation that he finds himself in and has not taken the necessary precautions that we can point to that person as having failed.

The question is therefore:

- How do we ensure that such simultaneities of factors that can result in accidents do not arise?
- How do we create awareness that “simultaneities” can occur so that people have an opportunity to take the appropriate action?

- How do we ensure that people what they should do when they are in situations where a simultaneity of factors arises that can lead to an accident?

It is a question of knowledge and competence, of the ability to act and of the willingness to be vigilant.

1.1.3 Accident risk

It is necessary to know initially the situations in which a risk of accident is associated. The Dutch WORM project in its analyses of in excess of 9,000 serious occupational accidents identified 64 hazards, cf. Chapter 3.

The Danish project has worked with these 64 hazards and grouped them in a way that makes this knowledge simple to use, cf. Chapter 5.

The hazards have been divided into

4 - 17 - 64 groups respectively.

The first stage that consists of dividing the hazards into 4 includes the following situations:

- A. The surface that is being travelled on or being worked on, i.e. be careful, risk of falling
- B. The surroundings that are being travelled or worked in, i.e. see if there is a risk in your surroundings of something colliding with you from outside, or of you colliding with something, etc.
- C. What is being worked on or with, i.e. look at what you are working on and the risk of you becoming caught up/jammed in something, stabbing yourself, cutting yourself, straining yourself, etc.
- D. Surroundings of a particularly dangerous nature. i.e. conditions that require particular vigilance.

The second stage that consists of diving into the 17 risk situations as follows:

A.	<ol style="list-style-type: none"> 1. Work at height 2. Work at the same level
B.	<ol style="list-style-type: none"> 3. Work where objects can fall 4. Work where objects can fragment 5. Work where you can be struck by objects, collide with something or become caught up/jammed in something 6. Work where you can become buried 7. Work with people and/or animals
C.	<ol style="list-style-type: none"> 8. Work with machinery and tools 9. Work with/on vehicles 10. Work with/in the proximity of electricity 11. Work with/in the proximity of heat and/or cold

	12. Work with/in the proximity of chemicals 13. Work with heavy lifting
D.	14. Work with/in the proximity of high voltage 15. Work with/in the proximity of flammable materials or processes 16. Work where there is a risk of suffocation, lack of oxygen 17. Work with/in the proximity of explosive materials or processes

The third stage that consists of diving into the 64 risk situations as follows:

<i>Characteristics</i>	<i>Activity</i>	<i>Risk</i>	<i>Hazards</i>
A. The surface that is being travelled on or worked on;	1. Work at heights	Falls from heights	1. Falls from heights - movable ladders
			2 Falls from heights – fixed ladders
			3 Falls from height – stepladders
			4 Falls from heights – rope ladders
			5. Falls from heights – mobile scaffolding
			6. Falls from heights – fixed scaffolding
			7. Falls from heights – erection/dismantling of scaffolding
			8. Falls from heights - roofs
			9. Falls from heights – areas, floors with large differences in level
			10. Falls from heights – fixed platforms
			11. Falls into deep holes (e.g. in the earth, floors)
			12 Falls from heights – mobile platforms
			13. Falls from heights – stationary vehicles
			14. Falls from heights – other work at height without protection
B. The surroundings that are being travelled on or worked on;	2. Work at the same level	Falls from the same level	15. Risk of stumbling or skidding on the same level
			16.3 Falls from steps or inclined surfaces
	3. Falling objects	Being struck by falling objects	17 Being struck by falling objects – cranes or hoists
			18. Being struck by falling objects - mechanical lifting (e.g. cranes)
			19. Being struck by falling objects – from conveyances or conveyor belts
			20. Being struck by falling objects – from manually lifting
			21. Being struck by falling objects – other objects at height
	4. Fragments	Being struck by fragments	22. Being struck by fragments – from machinery or hand tools
			23. Being struck by fragments – from objects under pressure/stress
			24. Being struck by fragments – that are blown by the wind
	5. Colliding against, between, being struck by	Being struck by moving objects, becoming caught up/jammed, crushed.	25. Collision with vehicle
			26. Being struck by rolling/sliding objects
			27. Being struck by hand tools held by another person
			28. Being struck by objects held by another person
			29. Being struck by swinging objects
			30. Becoming caught/jammed between objects
	6. Sliding of materials	Becoming buried	31. Colliding against/with objects
			32. Buried under loose material
	7.	Violence	33. Exposure to aggressive people (violence)

Characteristics	Activity	Risk	Hazards
	Aggression		34. Exposure to the behaviour of animals (falls, bites, stings, kicks)
C. What is being worked on or with;	8. Technical aids	Being struck by moving objects, becoming caught up/jammed, cutting	35. Being struck by own hand tools
			36. Being struck by moving parts of machinery - operating
			37. Being struck by moving parts of machinery - maintenance
			38. Being struck by moving parts of machinery - preparing
			39. Being struck by moving parts of machinery - cleaning
	9. Vehicles	Collisions	40. Loss of control over vehicle
	10. Electricity	Electric shock	41. Contact with electricity – electrical equipment
			42. Contact with electricity – when installing/repairing
	11. Heat or cold	Burns	43 Burns - frostbite/burns from cold/hot surfaces or naked flames
			44 Fires – combustion from “hot” work
	12. Chemical	Poisoning, etching	45. Discharge of hazardous chemicals from open containers
			46. Contact with uncovered hazardous chemicals (without discharge)
			47 Release of chemical risk from closed containers - work/filling/draining
			48 Release of chemical risk from closed containers - without transportation
			49. Release of chemical risk from closed containers – when closing containers
	13. Lifting, heavy loads	Strain injuries	50. Release of chemical risk from closed containers – work in the proximity of a discharge
			51. Extreme exertions – heavy lifting
D Surroundings of a particularly dangerous nature.	14. High voltage	Electric shock	52. Extreme exertions – inappropriate movements
	15. Fire	Fire	53. Contact with electricity – high voltage cables
			54 Fire – flammable and easily combustible substances
	16. Lack of oxygen and water	Suffocation, poisoning or drowning	55. Fire – fire extinguishing
			56. Suffocation/poisoning – work in confined spaces
			57. Suffocation/poisoning – work with respirators
			58. Drowning – work in/under the water or liquids
			59. Drowning – work above/in the proximity of water
	17. Explosion	Explosion	60. Physical explosion
			61. Chemical explosion – vapour or gas
			62. Chemical explosion - dust
			63. Chemical explosion - explosives
			64. Chemical explosion – exothermic reaction

These risks are therefore a result of an analysis of a large number of accidents and thereby form a good basis for an application of the knowledge gained from these accidents. This knowledge can be used to assess the risks that can be encountered in different situations and how to assess the possibility of a simultaneity of factors occurring that could lead to an accident.

1.1.4 Application of this knowledge

Many people will say that we are well aware of the sources of risk and that we are also vigilant of these risks. However, the advantage of having them specified and grouped, as shown above, is as following:

- There is a structure to accident risks that can be used to assess the risk and in particular for drawing up an APV of the accident area.
- There is a complete listing that ensures that you can cover everything in a systematic way.
- This is a step by step approach to the many different types of risks that allows one step to be worked on at a time and in this way limits the amount of data that will be looked at in a step by step analysis.

It is recommended that the company's APV is structured for accidents using the three steps shown in the paragraph above in order to ensure that all accident risks are examined in a work place assessment.

In connection with this it should be remembered that the individual risks will be present at any given time. They will occur ad hoc during a period of work, which means that the co-workers' actions at work will need to be followed over time in order to ascertain which risks they are exposed to and the duration of the exposure. It is necessary to know the extent to which the co-workers are exposed to accident risks during the course of their working day.

One method of charting this is by simply asking each employee questions, however a proper survey can be conducted by using the electronic tool for risk observations, which was developed during the DanWorm project, cf. Chapter 5.

This is a small program that can be incorporated into a PDA and which will allow you to follow a person through the course of one or more working days and thereby record their risk exposure.

There is also the option of using the average risk exposure, which resulted from the Dutch project in its extensive survey of 30,000 employees in The Netherlands.

The Dutch project has worked out a number of diagrams that show the risk exposure within a number of industries and trade groups, which is one set of results from the Dutch project.

Such a survey of the accident risk and risk exposure is a necessary tool to:

- know how a change should be made in order to reduce the accident risk in a company,
- to be able to monitor and conduct audits with a view to determining whether the initiatives that are implemented cf. Chapter 6 have been fruitful.

1.2 Prevention by means of safety barriers

1.2.1 The message

It is impossible to remove and minimise all risks. Accident risks will always be present where people travel, act, work, develop and live. Accident prevention is not about achieving ZERO risk, but rather about achieving ZERO accidents.

This is achieved by ensuring that safety barriers are designed appropriately, that they are installed and functional, that they are cleaned and maintained, that instruction in their use is provided and finally that people are motivated to act in a safe manner.

1.2.2 Background

A safety barrier is something that prevents an undesirable event or action from occurring, or something that is able to limit the harmful consequences of the accident, cf. Chapter 2.

A number of different methods have been developed to discuss and describe safety barriers.

Firstly, there is the one that quite simply divides safety barriers into passive and active barriers.

- Passive safety barriers are those that are incorporated into the technology, process, procedures, etc. and which prevent undesirable events from occurring. These include technical safety precautions, automatic process procedures, targeted safety routine, etc.
- Secondly, active safety barriers are those that need to be learned by the individual so that he or she through his or her behaviour prevents undesirable events from occurring. These include safety instructions, safety procedures, safety standard and routines.

Another way of viewing the safety barriers is by their mode of operation. We talk about preventative safety barriers, protective safety barriers and limiting safety barriers.

- Preventative safety barriers are those that passively or actively ensure that neither undesirable events nor undesirable actions occur, cf. above.
- Protective safety barriers are those that protect the individual from becoming injured, even if an undesirable event or action occurs, such as a line or net should the individual fall, a helmet should something fall from a height, goggles or clothing where harmful particles, etc. are being sprayed.
- Limiting safety barriers are those that can contribute to limiting an injury should the accident occur. These include rapid first aid response, sprinklers in the event of a fire, eye protection to protect the eyes against splashes, etc.

The most developed way of viewing safety barriers is by looking at their nature and function. Here safety barriers are broadly defined as something that can have both a physical nature and something that has an influence of people's behaviour.

With regards to physical safety barriers, the importance of the following is pointed to:

- That they are constructed and designed appropriately
- Installed according to purpose,

- Used as prescribed,
- Checked continually and
- Maintained in good condition

With regards to behavioural safety barriers, factors that can exert an influence over people's behaviour are pointed to. These are:

- Procedures, plans, rules and goals
- Availability of good personnel and planning
- Competences and adaptation of personnel and tasks
- Commitment, involvement and endeavouring to resolve conflicting situations
- Coordination and communication

1.2.3 Risk-safety barriers-quality parameters

In total in excess of 9,000 accidents were analysed during the Dutch project. This was done with the aid of an electronic program called "Storybuilder" that allows the course of events of accidents to be recorded in a structured format and at the same time indicates the safety barriers that failed in one way or another.

The model behind this program is called a "Bowtie model" since it can be illustrated as a bow tie, cf. Chapter 3.

The centre of the event is first defined, which corresponds to the damaging hazards indicated above.

The right-hand side of the analysis is an impact analysis where the consequences of the accidents for each damaging source of danger are charted. Any protective and limiting safety barriers that have failed or been inadequate are included here.

The left-hand side of the analysis is a fault tree analysis where all of the correlations that resulted in the source of danger causing the injury are charted. The preventative safety barriers that have either failed or been inadequate are included here.

On the basis of this analysis 64 generic "bowties" were produced that describe the hazards and their requirements for safety barriers on one side and the seriousness of the consequences on the other.

The results are as follows:

An identification of the most important physical safety barriers that are associated with each source of danger, supplemented by the behavioural safety barriers in the form of the individual's ability to act in a safe manner.

An assessment was also made of whether the problem with the physical safety barriers had been:

- Obtained and was therefore present
- Used and used correctly
- Maintained and in good condition
- Monitored and checked

And for all safety barriers there was an assessment of managerial factors such as:

- Inadequate procedures
- Inadequate equipment
- Poor ergonomic design of equipment
- Availability of equipment
- Inadequate competence
- Inadequate communication
- Inadequate motivation and involvement
- Inadequate solutions to conflicting situations

These assessments have resulted in the drawing up of a series of quality parameters that are used to establish the effectiveness of each safety barrier. In the Dutch project these quality parameters were termed “PIEs”, which stands for “Probability Influencing Entities”, i.e. factors that are of significance to the probability of a safety barrier failing, which influences the probability of an accident occurring, cf. Chapter 3.

The Dutch project has made the entire list of 64 hazards with indications of all significant safety barriers and associated quality parameters based on the 9,000 analyses conducted in The Netherlands.

1.2.4 Application

The most difficult aspect of observing accident risks is the fact that risks vary over time. They are influenced by an infinitely large number of factors and change from day to day, from job to job. They are present within tasks of a very short duration, the conducting of an APV for which has not been considered.

It is therefore difficult to predict all risks and it is difficult to predict when the simultaneities can occur that result in an accident. The alternative it to ensure:

1. that the most important physical safety barriers are:

- Obtained and put in place
- Used and used correctly
- Maintained and in good condition
- Monitored and checked

2. that the managerial conditions that will support both the behavioural and the physical safety barriers are in place.

In doing this we are able to shift our focus from risks that may be difficult to observe and control to a focus on the safety barriers that lend themselves much more to being observed and controlled, especially if the quality parameters at present at a high level.

That is to say that the APV and auditing, risk assessments, etc. are able to control the safety barriers and their quality parameters rather than control risks.

In this way we will have managed to create an overview, by means of analyses and a structured procedure, of what should be risk assessed and how this assessment is to be conducted.

The Danish programme developed for a PDA that is discussed in Section 1.1.5 allows the safety barriers for each individual source of risk to be recorded and for the quality parameters of each safety barrier to be assessed, cf. Chapter 5.

1.3 Prevention by means of risk awareness

1.3.1 The message

Since there will always be risks in our everyday lives that do not usually result in accidents, people often believe that this will always be the case and consequently become blind to risks.

By increasing our abilities to see risks and safety barriers as well as to continually assess their quality parameters, we can create a greater degree of risk awareness amongst employers, managers and employees.

A greater degree of risk awareness amongst those involved will enable us to:

- Continually recognise and control risks,
- Discover and deal with new risks
- Keep the safety barriers intact
- Replace one safety barrier with another should it become necessary to remove this safety barrier
- Control and maintain the quality parameters of the safety barriers

This will contribute to maintaining a high level of safety and prevent accidents from occurring.

1.3.2 Background

Part of the proactive prevention consists of making people aware of the risks associated with a situation at a given time and place and being able to observe and assess whether the relevant safety barriers are in place and in order. This can be termed a "Situational Awareness" (SA), which is an essential ability that people must possess in order to be able to perform their jobs safely. Such a SA places a number of demands on the individual, his or her work conditions, the management, supervision, training, knowledge, experience, motivation, etc., cf. Chapter 2.

A critical parameter of an SA is often the time that is available from the initial indication that something is about to happen or is not as it should be until the time that an inopportune event occurs. In addition, the dynamics of the majority of situations mean that there is always a need to understand and evaluate changes, to observe details and information, to transform this information into an understanding and review your perception of the situation and its possibilities henceforth.

People are also limited by their work-related memory and awareness and by their understanding and prioritisation of information that they perceive to be the most important. Customs go hand in hand with mental processes, where experiential decision-making uses customs and traditions to understand situations and to react to them.

Expectation, understanding and motivation are based on what the individual perceives as being important. It is therefore appropriate to influence the individual's expectations and acknowledgement of risks and safety barriers through instruction, training and communication of goals and consequences.

A simple 4-stage division of competence levels of people can be used with advantage to assess who is in need of instruction and training:

- Step 1 - Unconscious Incompetence, where the individual does not know what he or she needs to know.
- Step 2 - Conscious Incompetence, where the individual knows what he or she needs to know but does not yet possess this knowledge.
- Step 3 - Conscious Competence, where the individual knows what he or she needs to know and also actually knows this, i.e. the professional person.
- Step 4 - Unconscious Competence, where the individual knows what he or she needs to know and knows this, but reacts automatically, which can lead to inattention.

The majority of young people and new employees typically belong to groups 1 and 2, which may explain why they are more prone to meet with accidents than other more experienced people. Whilst we can also see in the statistics that there are a proportion of older people who meet with accidents, even if they have been in the same job for many years, which could suggest that they belong to group 4, i.e. they are unable to maintain the necessary awareness of changes.

This must at the same time been seen in the light of the fact that the majority of accidents are due to risks that are underestimated as they do not usually result in accidents, or when they do so do not cause serious injuries. This applies to risks such as the risk of falling, collision, handling loads, operating tools and technical equipment, etc.

We are much more careful when working with hazardous chemicals, materials where there is a risk of explosion or fire, heights, etc. since these immediately signal a risk of death or mutilation.

The result is that there are still many accidents, including serious accidents, that are caused by underestimated risks and gradually, quite a few accidents caused by the risks that are perceived as very dangerous, cf. Chapter 2.

1.3.3 INFOmap

To assist in creating a greater degree of risk awareness a number of INFOmaps have been devised in order to support instruction in situational awareness in relation to risks and safety barriers, cf. Chapter 5.

An INFOmap is structured for a specific risk area and includes:

- What is to be observed, what are the safety barriers
- What is to be assessed, what are the quality parameters
- What is to be acted on, which depends on the deficiencies that are discovered.

An INFOmap can be prepared for each of the 64 sources of risk and for specific tasks, technical equipment, if necessary.

In this report INFOmaps have been devised for the 17 risk areas, cf. Appendix A.

One result from the DanWorm project is an acknowledgement of what individual employers are able to observe and control in relation to each employee's work conditions.

The employer or the supervisor have a duty and an opportunity to ensure that the safety barriers are in order in advance, which procedures are in place, that training and instruction have been provided, that there is work being carried out in motivating employees to work safety, etc.

In order to accomplish this work the employer needs to be able to observe, assess and act in advance before starting the employees on their work tasks.

However, in many organisations, especially in medium and small organisations, the employees are left to their own devices when performing their tasks. Employees of, for example, handicraft organisations are away from the premises of the enterprise, i.e. have varying work locations and work conditions.

In these situations it is necessary for the employees themselves to be able to observe, assess and act instantaneously in the situations in which they find themselves and under which they are to work.

Two sets of INFOmaps have therefore been devised:

1. The first set is aimed at employers and supervisors, which will ensure that he or she ensures that the risks and safety barriers that can be secured in advance are secured in advance.
2. The second set is aimed at employees, which will ensure that he or she ensures that the risks and safety barriers that currently exist are secured.

cf. Chapter 5 and Appendix A.

1.3.4 Application

The INFOmaps can be used in a number of ways, but it is essential to show both the employer and the employee how risks can be observed and assessed as well as what actions are required.

The 2 x 17 INFOmaps can be considered as being very general and succinct. However, they have been devised to be used for the initial introduction and to create an understanding at a general level. The INFOmaps may even appear to be confusing when first encountered.

However, the aim is to create clarity of and accessibility to the knowledge about risks, safety barriers, quality parameters and to transform this into something that can be used in the daily work place.

The INFOmaps are intended to be used for the daily continuous assessment of risks that needs to take place in work places where risks vary from job to job and from time to time, etc.

However, the INFOmaps may also be used for instruction and training that can make employers, supervisors and employees more aware of risks, safety barriers and their quality parameters.

The INFOmaps may also be used to communicate the risks that are present particularly frequently in some jobs and the safety barriers and quality parameters that we should be particularly aware of in each job.

That is to say that the INFOmaps may be used both internally by the organisations themselves and by training establishments as well as by organisations and authorities to communicate their information.

1.4 Prevention by means of management involvement

1.4.1 The message

"Safety begins with management or it does not begin at all". If the management do not prioritise safety in a way that enables the employees to understand it and believe in it, the employees will not do so either.

Good safety can only be achieved when employers, supervisors and employees work out how to cooperate so that everybody becomes involved in the agreements and activities that need to be implemented in order to achieve safety. Only when this has been accomplished can commitment to and co-responsibility for safety throughout the whole organisation be created.

1.4.2 Background

A frequently employed preventative strategy that only investigate the accidents that occur and on the basis of this ensures that there is no repeat performance. This very reactive, preventative strategy has been termed "the Accident Cycle". What most commonly happens is that you relax after great efforts in achieving a decrease in the accidents statistics and then after a period of time accidents start to happen again to the great frustration of those who have made the efforts, cf. Chapter 2.

A better preventative strategy would be if the management were to decide that safety needed to be increased and put a series of campaigns and initiatives into operation in order to achieve a low level of accidents. If the efforts are clearly driven by the management with rules, incentives, penalties and instructions and the strategy is top-down controlled and is based on how well you perform in relation to the demands that have been made, the efforts will usually have an effect up to a certain level. In this way a new safety platform has been created that assesses on the basis of the number of accidents per million working hours and is termed calculating prevention.

With this proactive prevention focus is shifted away from looking at accidents and risks to looking at safety and safety barriers. It has been initiated and supported by the management but is driven by the employees and takes place in an interaction and cooperation between the two parties. The starting point is a thorough knowledge of risks, causes and indications that safety is not as it should be. This knowledge is coached and embedded into each employee as part of his or her professional foundation.

It is pointed out again and again in the literature that safety must be integrated into the whole organisation and function at all management levels and involve all employees in their daily work tasks. In this context transformational management is cited as being the most successful type of management in achieving low accidents frequencies.

When talking about management here, this refers to general, tactical and strategic management, which in large organisations may involve different people, while in small organisations this may be a single person. However, there are different types of considerations, decisions and actions at each of these three levels.

Two management styles in particular are cited as being effective in achieving a high level of safety.

1. Management through target management and positive feedback.
2. Change management.

These are both recognised management styles even if they are usually used in areas other than that of safety.

However, the literature has described some very positive experiences of the use of both of these management styles in organisations. Operating these management styles in conjunction with the development of a good safety culture will make very good sense.

The important factors that characterise a good safety culture are said to include:

- Commitment to safety and involvement that can both motivate and secure the necessary resources, etc.
- Competences consisting of access to the correct information and training so that the correct action can be taken.
- Awareness of the specific hazards, risk and safety barriers that are absolutely necessary elements in maintaining safety.

The following are also said to be just as important in achieving a good safety culture:

- A genuine and sustained management commitment to safety, that is to say prioritising safety over production, a sustained high profile at safety meetings, personal participation of the managers at safety meetings and in inspection rounds, face-to-face meetings with the employees with safety as the topic and completed job descriptions that contain a type of safety contract.
- Communication of safety topics, that is to say widespread formal and informal communication and regular meetings regarding safety issues between the top management, middle management, the general management and the employees.
- Involvement of the employees, that is to say allowing the employees to attend to safety issues, to delegate responsibility for safety and to encourage the employees to commit themselves to the organisation's target for the safety level.

1.4.3 Management tools

Safety is therefore a management task that must be integrated into the whole organisation and have the total involvement of the employees. It is a task that consists of many elements and which takes time to accomplish.

The tool developed by the Dutch WORM project for use by management in its prioritisation is an electronic calculation program (ORCA), which can show the risks present within an organisation, i.e. the probability of a serious accident occurring and the measures that are worth while implementing from an economic and risk perspective, cf. Chapter 5.

ORCA is available in two versions.

The first version is a "stand-alone" application that contains the full and very specific calculation program.

The second version is a simplified web-based system (WebOrca) that is a light version of the full ORCA inspired by the simplification developed by DanWORM. This web version is available in Danish, English and Dutch.

Web Orca is available by contacting www.weborca.nl.

In order to be able to perform the calculations, some information is required on the work that you wish the calculation to be performed on and the conditions under which this work takes place. This information is:

- Indication of the professional groups contained within an organisation, for example.
- Indication of the number of people included in each professional group and the number of these who are over 50 years old.
- Details of their working hours with hours per day, days per week and weeks per year.
- Division of tasks for each professional group. The purpose of this is to delimit specific work tasks that can be assessed for sources of risk, exposure times and the quality of the safety barriers.
- Indication of the risk situations/hazards associated with each work task given that the 4-17-64 risk situations can be chosen from.
- For each work task an indication of the amount of time used to perform the task as a percentage of the total working hours.
- An assessment of the safety barriers that the system identifies on the basis of the specified risk situations. A simple five-stage scale is used here, ranging from "poor-unreliable-average-good-excellent".

In other words, there is a need for quite a lot of information, both on the whole organisation and on each employee and his or her specific work tasks. In return for this a risk calculation and a risk profile are obtained that can clearly be used as prioritising tools for an organisation's initiatives regarding accidents.

The tools that were developed by the DanWorm project are the previously described methodologies used to chart APV, describe safety barriers and their quality parameters and the INFO maps that have been devised. In addition to this, the DanWorm project has entered into an ongoing collaboration with the WORM project, in particular into a dialogue regarding the presentation of data to make this data more easily accessible, cf. Appendices B and C.

1.4.4 Application

The various tools can be included in the management's strategy and implementation of initiatives to achieve a high level of safety and a good safety culture within an organisation.

In this report reference is made to a management concept that is a combination of change management and target management, i.e. feedback, cf. Chapter 6.

A change concept is suggested that comprises:

A learning process	in which all of those involved gain knowledge of the safety problems that really need to be resolved and how these should be resolved.
A political process	in which those involved in the process are assigned roles and responsibilities, possibly special privileges and powers and where a coalition of participants is established to measure the changes.
A symbolic process	in which a new culture is given an identity by means of symbols, rituals, rewards, story telling and its own language.

Integrated into this concept is the target management concept using feedback, cf. Chapter 6.

A four stage training programme is suggested.

1. Stage one is an educational programme in which instruction is given into risks, safety barriers and quality parameters as well as management objectives and prioritisations.
2. Stage 2 is a period of training on the job in which the knowledge that has been acquired during the educational programme is translated into a method for applying this new knowledge into daily work.
3. Stage 3 is an accessibility of all information, new knowledge, recovery of knowledge from the educational programme, etc. so that everybody knows where they can find the necessary information. This also includes knowledge about accidents, knowledge about materials and technical equipment, APV's that have been conducted, user instructions, etc.
4. Stage 4 is a recording and analysis of accidents and near misses that can be used in any subsequent reviews of the prioritisations and to keep an eye on any areas that the training has not fully reached.

A four stage organisation programme is suggested:

5. Stage 5 is the involvement of the employees in the changes that are to be implemented. This includes incorporating the employees' knowledge of risks into their daily duties and their opinions as to what is most important.
6. Stage 6 is to ensure a daily dialogue regarding safety between the employee and the general manager in order to create awareness of prioritisation and to maintain focus.
7. Stage 7 is a holding of toolbox meetings where there is need for special awareness of safety problems prior to commencing work. This is important, for example, when the tasks concern additional people and/or people from outside of the organisation.
8. Stage 8 is a review of risks and safety barriers in order to follow goals, strategies and initiatives and determine whether these have achieved results.

A two stage symbolic programme is suggested:

9. Stage 9 is a relatively frequent walkaround by the top executive where she or he will show his or her visibility and awareness of safety.
10. Stage 10 is a series of symbolic events that can create stories and pride and lead to the awarding of prizes, adulation and glory.

Tools and knowledge about risks, safety barriers and quality parameters have been developed in all of these stages and calculation programs and recording methods have been integrated where appropriate.

An idea can also be given as how the development of an APV should be tackled and to conduct an audit, cf. Chapter 6.

1.5 Prevention in small organisations

1.5.1 The message

The prevention of accidents in small organisations must be realised on the basis of the same principle that apply to large organisations but in accordance with small organisation conditions.

Where large organisations have an organisation and resources to implement targeted initiatives regarding safety, others outside of the small organisation must assist in creating the basis on which the small organisation is able to act.

A high level of safety in small organisations cannot be achieved until there exists a general desire for this an discourse in society.

1.5.2 Background

In Denmark in excess of 178,000 organisations with employees and in excess of 121,000 sole trading organisations are registered. Among the organisations with employees 85% have less than 20 employees, 10% between 20 and 50 employees, 3% between 50 and 100 employees and only 2% have more than 100 employees.

Hasle et al 2004 conducted a literature analysis that describes the problems associated with safety initiatives in small organisations, cf. Chapter 2 thus:

- That the safety within small organisations is largely determined by the culture and understanding that the employer and the owner of the organisation has in relation to the aspect of safety. It is the owner who is the focal point for the tasks and duties of the organisation and who is responsible for the way in which safety is prioritised and implemented into daily work. At the same time, the owner has many different duties that must be attended to in his or her daily work and he or she will usually perceive systematic work environment initiatives as one of the more peripheral duties.
- That systematic work environment initiatives in small organisations are usually limited, and that the same applies to all other types of systematic planning and management. The employer or the owner has a tendency to surrender responsibility for safety to the employees. The employer usually views safety as an individual problem and only the necessary safety equipment is provided.

- That it is important to recognise that employers and employees in small organisations are witness to very few accidents and therefore have limited opportunities of gaining their own knowledge of the hazards that can lead to accidents. For this reason, among others, the understanding that safety is an important topic is similarly limited.

- That over the last 5-10 years a number of different methods and tools have been developed, which have been trialled in small organisations, but the general experience is that it is difficult to disseminate and create interest in the results within small organisations. Small Organisations need to realise that these results provide them with something they can use in their daily work. Something that can make the average day a bit easier and which is immediately understandable as regards why and how these should use these results. It is also known that the employers of small organisation are motivated by personal contact and when they are given the opportunity to exchange experiences with colleagues.

- That small organisations in the traditional regulated market do not have the resources at their disposal that are required by the paperwork for a safety management system in a rule-based system. Employers within small organisations need to rely in their employees' abilities and the mutual more informal communication to a far greater extent.

Kogi 2006 has amassed a number of experiences of successful initiatives implemented within small organisations and has come up with two primary criteria:

- 1) that improvements are best achieved if local knowledge of best practices is used
- 2) and assistance is given in disseminating this knowledge via dialogue between local groups. In connection with this, the importance is highlighted of the objective for the small organisation being the use of good local practices, to be shown self-help actions at a low level of cost and to provide an experienced facilitator with support for a continuous process.
- 3) That a starting point has been taken in the positive features of small organisations that include the informal style of management. Also the use of local people as we communicate best with people that we already know.

This is illustrated by a five stage action plan:

1. To learn good local practices through good examples via photographs, video, brief descriptions
2. To check up on practical solutions, action checklists and lists of low-costs ideas.
3. The implementation of simple improvements using available action manuals on how to act quickly and with ease without the need for a large number of resources.
4. To confirm the gains by means of, for example, success stories, recognition, any easing with regards to the authorities and insurance.

However, the first major problem in starting a process is creating an understanding within the small organisation that safety is important for the organisation and that an initiative into this area should be prioritised cf. Chapter 2.

1.5.3 DanWorm observations

The goals of the DanWorm project include investigating the opportunity to use the results from the WORM project so that these may be used by small organizations, cf. Chapter 4.

The first acknowledgement is that the electronic calculation program (ORCA) is too complicated and requires too much information in order for a small organisation to want to use it.

The conclusion is that other people will have to collect the information and present the results to the small organisation. The DanWork project has conducted two case studies in which the data for two professional groups has been gathered, namely carpenters and caretakers.

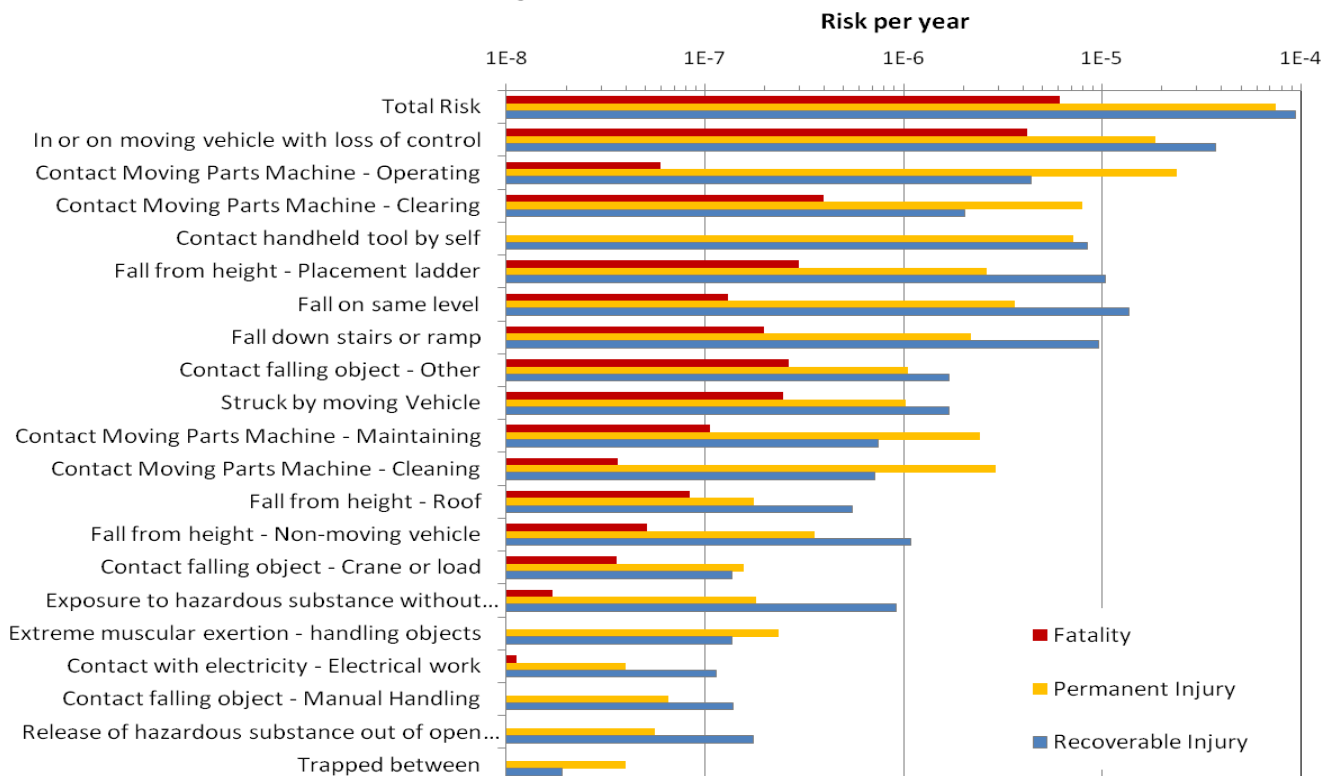
Data has been gathered on the risk exposure, safety barriers and quality parameters for these two professional groups. Data has also been input into ORCA, which can then display a general risk profile for the work of the two professional groups in small organisations.

For this purpose the structure of the 64 risks in the 4-17-64 classification has been developed as a suitable method with which to conduct a systematic risk observation.

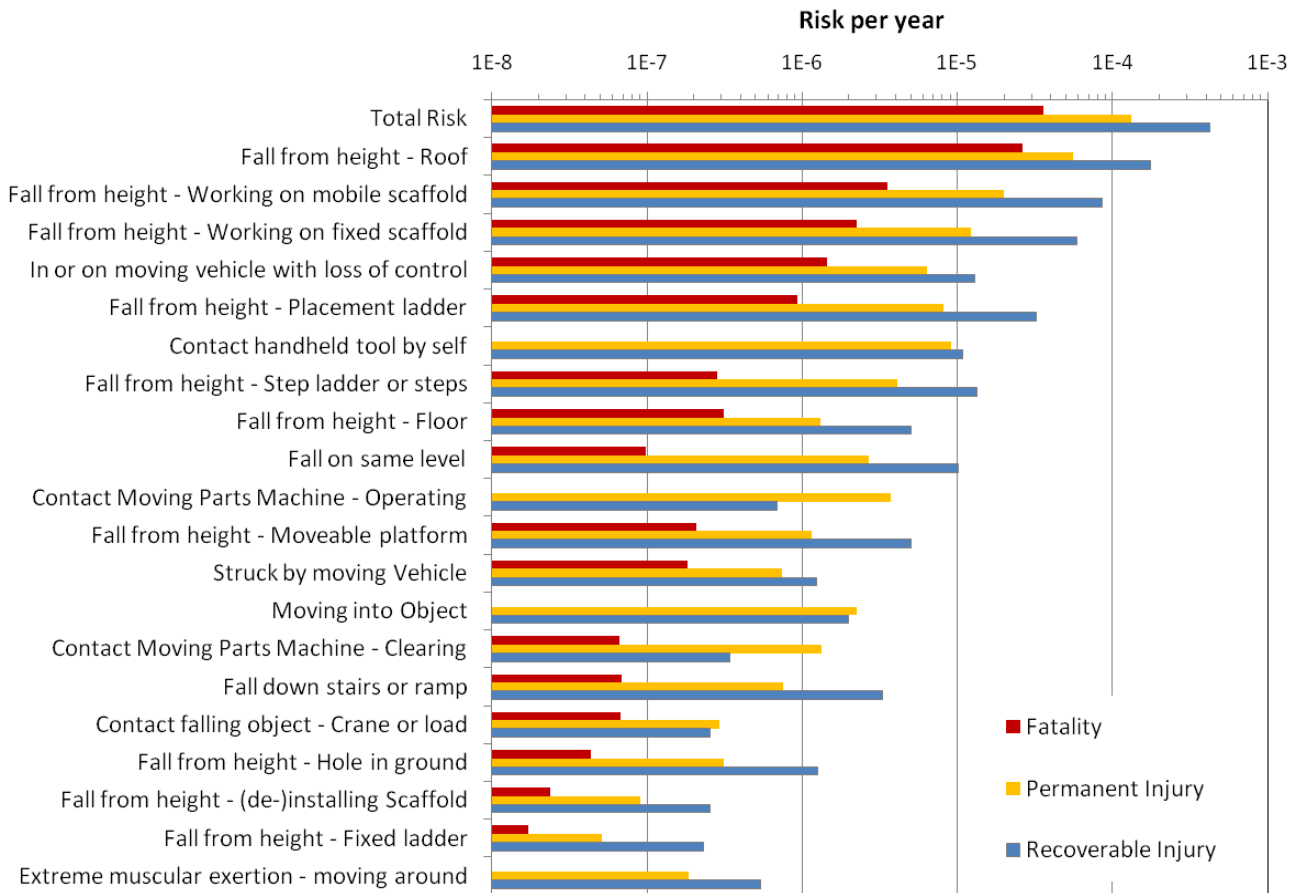
The observation program for PDA has also been developed as a tool to enable a work environment expert to conduct observations.

Observations have been conducted for a total of 20 individuals per professional group, where each individual is monitored over the course of three whole work days. That is to say that 60 days of observations were conducted for carpenters and caretakers all of whom were employed in small organizations, cf. Chapter 4. Finally, observations were conducted for a total of 20 individuals per professional group, where each

Risk profile for caretakers



Risk profile for carpenter



1.5.4 Application

The DanWorm project has in this way discovered a method to devise risk profiles for employees of small organisations to provide them with an insight into which areas they should focus on from a safety perspective.

A simple information tool has been developed in the form of INFOmap to determine what should be observed in the daily work and the appropriate action to take.

In all of the small organisations in which DanWorm has conducted observations an organisation report has been produced with 10 points of recommendations for the employer and the employee.

However, the DanWorm project has not intervened in these organisations, i.e. the results were not tested in the organisations in order to see if there was anything that they thought needed working on, or if such knowledge would change anything at all in their method of planning and performing work.

The small organisations that participated in the DanWorm project are characterised by having a certain prioritisation of safety, which was the reason why they agreed to participate in the project.

On the other hand the demands of the working day were such that there were no resources for much else than showing interest and friendliness. All were invited to receive a further introduction into the meaning of safety and accident prevention. All gave the impression of wanting to hear about this and that they wanted to find a time to assemble all employees for a joint dialogue. None have contacted us in order to implement the initiative.

This is not because they do not want to, but there are not the resources for anything that is still seen as being a little unnecessary. That is alright.

A targeted initiative at industry level could be conducted by industry associations where work environment professionals could assist in the development of industrial risk profiles and a dialogue about the risks that it is important to take action over.

Small organisations are so varied and so numerous and with different cultures, resources, prioritisations, etc. that the initiatives to motivate and create focus need to take place at a general level, i.e. nationally or perhaps at industry level.

1.6 Future research and development

The Worm and DanWorm projects have resulted in expanding our knowledge of risks, safety barriers and quality parameters for the prevention of accidents.

However, as has been stated, it is not sufficient to have knowledge and tools. Knowledge needs to be disseminated, opportunities need to be created for its use and there needs to be a desire for safety.

There is still insufficient research into how this could be achieved in these areas, with regards large and small organisations.

Chapter 2. The theoretical basis

"Knowledge is prediction – Prediction is prevention" (free quotation from Sartre), this is a perspective that fits in with the prevention of occupational accidents. However, the question is how do we create such knowledge. A good deal of research has been conducted into the causes of accidents and their prevention over the last 100 years with a development from identifying those who are prone to accidents for the technical measures and onto looking at human behaviour, to more systematic and safety-cultural forms.

This section does not provide a complete review of this research, but is rather an attempt at gaining a contemporary overview of the most recent theoretical approaches to understanding the causes of accidents and to achieve improved safety at work. This should also be placed into the context of the small organisation and its opportunities for creating safety for its own employees.

The theoretical basis is illustrated by three approaches:

1. The first part concerns an understanding of occupational accidents as a concept and the mechanisms behind the explanations of causes and consequences. Here the starting point is the accident and the knowledge that can be gained by looking at what has occurred. The goal is to create an understanding for the elements that need to be activated in order to achieve a proactive prevention of accidents.
2. The second part concerns an understanding of safety initiatives within organisations consisting of the knowledge of proactive prevention before the accident has occurred. This focuses on areas such as management, behaviour, securing of safety barriers and safety culture.
3. The third part concerns the small organisation, its style of management and function and the research that has thus far been conducted into safety and accident prevention in small organisations.

2.1 An understanding of the occupational accident and its causes

In order to be able to prevent accidents it may be appropriate to understand how they can happen before they happen. However, the possibilities of the occurrence of an accident are manifold and therefore even if we believe that everything is as it should be, accidents will happen, just like a flash out of the blue. The surprise and the acknowledgement that we were unable to cope with the situation and foresee what could have gone wrong means that there is a large focus on investigating accidents when they occur. This is often connected with establishing responsibility, but an investigation into an accident can also provide us with a good basis for learning.

Investigations and analyses of accidents have produced both method-based and theoretical models that attempt to create order in the numerous conditions of significance should an accident occur. In this section the most important results from the last few years will be presented.

2.1.1 The concept of the Occupational Accident

Within the field of accident research attempts have been made to define and describe "the accident and the occupational accident" in a number of different ways. However,

common to the definitions is that the sequence consists of, to a lesser or larger extent, the causes, the critical event and the subsequent consequences (Rasmussen 1997, Jørgensen 2002). In this report the following concept is defined as:

The Occupational Accident

A sudden and unexpected event or series of events occur or occurs when work is performed that results in something injurious causing injury or damage to people, materials, processes, etc.

Related to this concepts such as the near miss and dangerous situations and dangerous actions have been developed as important elements of prevention.

These two concepts can be defined in parallel to the concept of the accident in the following way (Jørgensen 2002):

The near miss

"A sudden and unexpected event or series of events that contains or contain something that can cause injury or damage, but due to fortuitous circumstances does not have injurious consequences".

Dangerous situations and dangerous actions

" Situations or actions that have the potential for the occurrence of sudden and unexpected events, which contain a source of danger that can cause injury or damage".

This concept particularly related to the event "Accident" and a delimitation of the levels from the potential event to the event that leads to an undesirable consequence.

A further two concepts will be presented, namely the concept of Danger – Hazards and the concept of risk.

Danger – hazards

"Danger or a source of danger is usually placed in relation to one or another type of energy that can cause injury or damage if it is released in an incorrect manner".

The danger therefore lies in our losing control over the energy. Here energy can be understood in a very broad sense in order to cover all of the types of injurious circumstances that can cause injury or damage in a sudden and unexpected event.

Risk

" The concept of risk is usually expressed as the probability of a given undesirable consequence occurring".

However, the concept of risk is not a precise concept and is dependent on who the risk concerns and what the risk comprises. What represents a risk to one individual can quite easily represent an advantage to another individual, cf. Section 2.1.4.

2.1.2 The hindsight of accidents

Kirkegård's theorem that life is understood in reverse but must be lived in forward, expresses a central problem in the attempt to understand the causes of accidents and their prevention. With the benefit of hindsight it is always easier to understand why an accident occurred. A good question is how can we identify and assess a risk for an accident and not least foresee the possible consequence that an accident could involve and be able to act on this basis.

But how do we foresee that an event will occur at this very time and place and affect this or these very individual or individuals?

Generally we are unable to do so and this is why we have to use other aids in an attempt to prevent an accident. We may well believe that there is a possibility but not necessarily know where and when.

In the previous research into occupational accidents the research was targeted at the individual, i.e. the victim as it was believed that the individual was the cause. He or she could of course have acted more appropriately and could have foreseen the situation. This view that the injured party "is to blame" is still prevalent even though research has long since departed from this view of the cause of accidents.

The reason is that each specific accident often occurs in situations that are "common", i.e. situations that are well-known to the injured party and those in his immediate surroundings. Where it can be obvious after the fact what he or she "did wrong" in the situation or what he or she should have done differently. However, the question is whether it is correct to predict the correct and incorrect way for the injured party to act by noticing before the accident occurred and whether he or she is able to act differently.

When a person takes a chance in a situation there are always a series of fact that motivate the person's actions (Krause T.R. 1995). As an example of this is the following analysis:

" A group of repairmen fail to collect a ladder when they are about to repair some pipes. They instead climb up onto railings to reach the pipes."

An analysis of the causes of this behaviours include:

1. The work group has a lot of tasks to complete and is under time pressure.
2. There is limited access to ladders that can be used.
3. It is a long way to where the ladders are to be collected.
4. The group has the attitude that that they can easily manage the task.
5. None has otherwise received any form of training or instruction into how the problem is to be solved.

An analysis of the consequences of the chosen behaviour shows the following picture:

1. Since the group decides not to spend time in collecting a ladder they will complete the task faster.
2. In this way the group will be able to have a longer break before the next task.
3. There is a risk of somebody falling, but this rarely happens.
4. By being able to work without using a ladder the group feels that they are mastering a difficult task and are therefore capable.
5. The group also avoids having to wait around until one of the others collects the ladder.
6. The group avoids further work pressure from their supervisor as they complete the task quickly.

As can be seen, there are a large number of good reasons for the risky behaviour and a number of positive consequences that contribute to the group's choice of method. Only when and if somebody falls down will they all be able to see that they should have allocated time to collecting a ladder.

In the majority of accidents a thorough charting of the course of events shows that there is always a series of causes that explain why the accident occurred

(Andersen 1991, Rasmussen et al 1987, Jørgensen 2001, 2002). There is therefore a series of sequences of causes and a simultaneity of causes that create the accident. This can be illustrated by an example:

"A trainee chef suffers burns to his foot and ankle when he steps on a saucepan lying on the floor containing a scolding hot meal". The saucepan has been placed on the floor at the end a cooker. There are other people working on both sides of the cooker and at some of the cooker plates. The trainee chef is performing a task that requires him to operate cooker plates on both sides of the cooker. It is very busy. What usually happens is that saucepans containing prepared food that are awaiting being taken away are placed on the floor under the cooker and not beside the cooker".

The accident analysis that applies a fault tree analysis shows the following sequences as the series of causes to the consequences of the accident, see Figure 1:

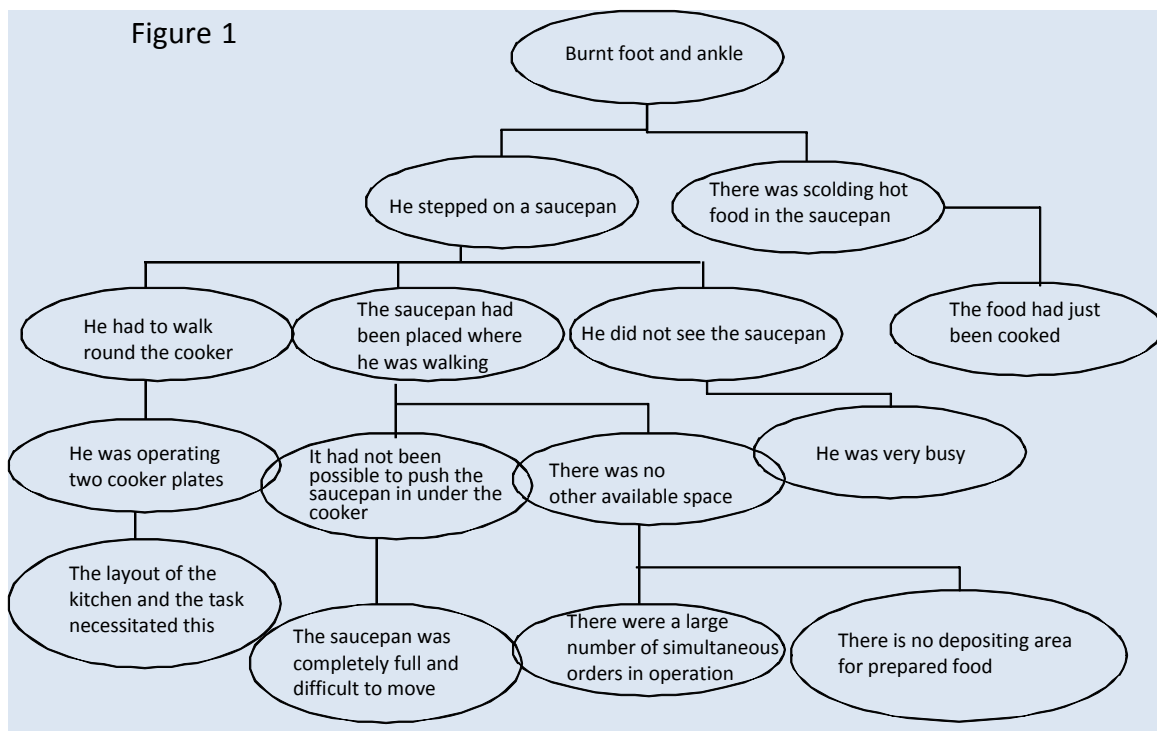


Figure 1 illustrates a fault tree analysis for the accident example of the trainee chef who burnt his foot.

The example can illustrate, among other things, that the individual causes is not in itself sufficient for the accident to occur. For example, he would not have fallen over the saucepan if he did not have to go round the cooker or if he had seen the saucepan. Nor would he have fallen over it if it had been pushed under the cooker. It is therefore the simultaneity that is the "guilty party", i.e. the fact that he had to go round the cooker, the fact that there was a saucepan where he was walking and did not see it.

The phenomena can be compared with an image of a Swiss cheese with holes (Reason 1997). The accident occurs when the safety barriers have “holes”, i.e. are not working properly, and that these “holes” occur simultaneously, which results in a latent risk becoming an accident and resulting in a loss.

Figure 2

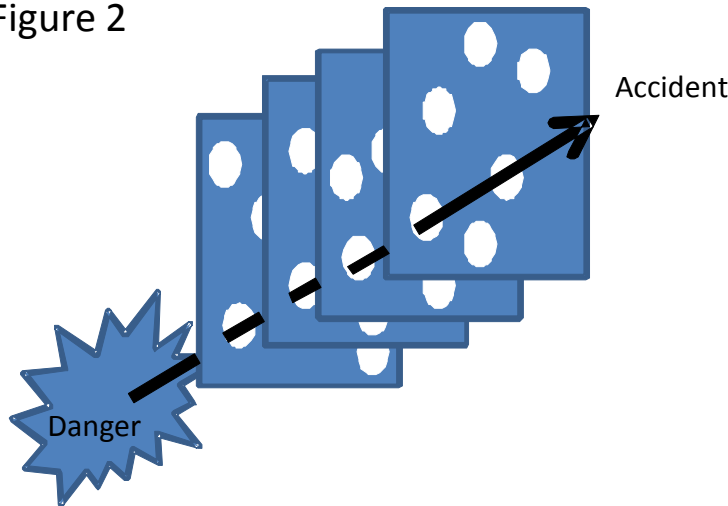


Figure 2 shows Reason's model for the path from risk to accident by the Swiss cheese with holes in the safety barriers (Reason 1997).

This "simultaneity" of barrier failure is basically what creates the opportunity for the accident to occur. For large technical devices this can possibly be something that can be taken into account, but for the more common, day to day accidents this is an unknown quantity as there are a vast number of ways in which the safety barriers can fail. This is difficult for an individual to predict in an instant. This also means that if we want to safeguard ourselves against all causes, this will immediately make our daily lives very complicated and we do not of course want to be wrapped in cotton wool.

There is always risk where people are present and travel. The individual learns from childhood what is dangerous and what can cause injury. For example, it is well known that a knife can cut, that a fall of two metres can cause injury, that ice is slippery and makes it difficult to keep balance, that a hot plate can burn, etc. Despite this accidents do happen again and again through such fairly commonplace hazards.

Is this because people do not understand how to behave appropriately and does this lead us back to the old fashioned view of the accident prone person? It is frequently said that in order to prevent occupational accidents "human behaviour" needs to be looked at. The only problem is that this has been done for a very long time without it having been of any significant help to the occurrence of accidents. However, let us nevertheless look at what the research has to say about human errors and faulty actions, which have been in particular focus within the area of "Major Hazards".

2.1.3 Errors and dealing with errors

Since it is people who operate, maintain, design and manage technological systems, it is difficult to get round the fact that when something happens that should not happen, one or more people at one place or another within the decision-making and action process should have made different decisions and acted differently. In principle every error within a manmade system is a human error. Therefore we also see evidence for a minimum of 90% of all accidents being due to human errors and therefore reach the logical conclusion

that human behaviour needs to be addressed. However, the question is which people and at what point in the decision-making chain do the faults occur, which will not be answered here. The following is just a description of different ways to view faults and incorrect actions.

Over the years a number of researchers have attempted to identify and categorise faults and incorrect actions. (Rasmussen 1987 et al) talks about cognitive levels, as:

- Experience-based errors, i.e.
 - errors in performance
 - errors in memory
- Rule-based errors (incorrectly applied rules)
- Knowledge-based errors and misunderstandings

This categorisation is further illustrated by Reason (1990) by the following model, Figure 3:

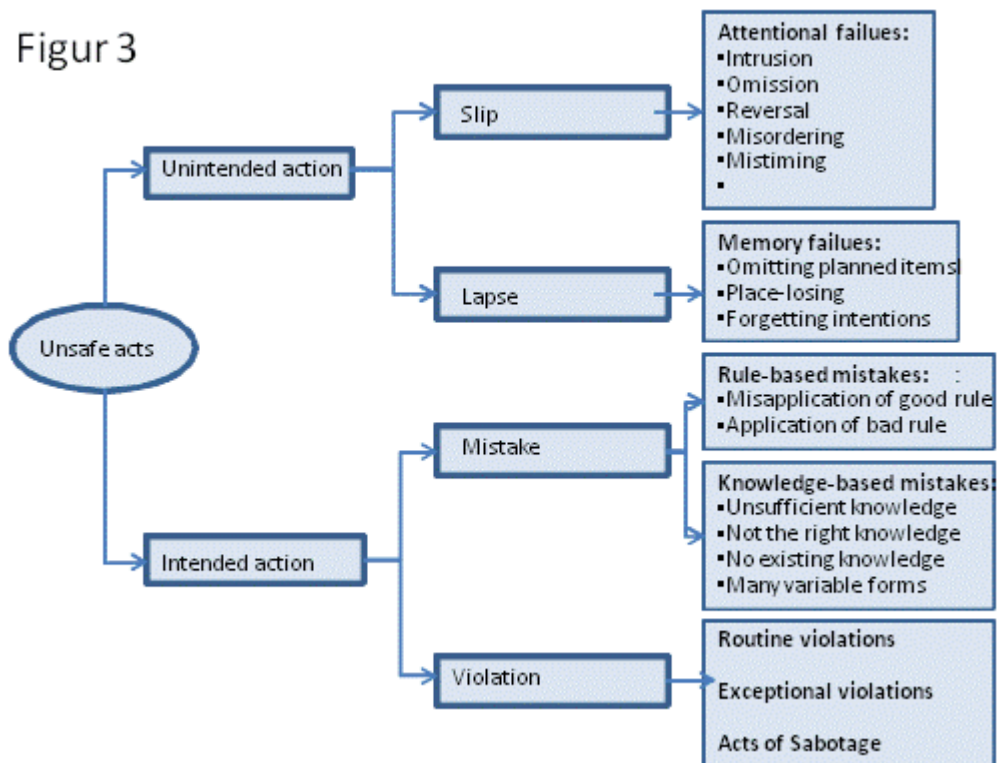


Figure 3 shows Reason's structure and understanding of errors and incorrect actions, (Reason 1990)

Others have compiled lists of errors types, among these, Koornneef offers the following categorisation of error types (Koornneef 2000):

1. Materials and equipment, such as faulty or incorrect equipment, faulty or incorrect materials, faulty reinforcement, welding, soldering, etc., faults in the manufacture of the consignment and labelling, electronic or instrumental noise, contamination.
2. Procedural problems, such as faulty or inadequate procedures, lack of procedures.

3. Personal errors as a consequence of an inadequate work environment or other personal-related errors, such as inattention to detail, non-compliance with requirements or procedures, verbal communication problems.
4. Design problems, such as insufficient human-machine interface, faulty design, incorrect choice of equipment or materials, errors in diagrams, specifications or data.
5. Training or education faults, such as no training provided, inadequate practical and hands on experience, inadequate content, inadequate re-training, inadequate presentation of the material.
6. Management problems, such as inadequate administrative control, inadequate planning and organisation, inadequate supervision, inadequate resource allocation, inadequately defined, communicated or implemented policy, other management problems.
7. External problems and phenomena such as the weather and other problems in the surroundings, energy failures or short-term energy supply, fire or explosion, theft, sabotage, vandalism or forgery, etc.

These error types can in many ways be compared with the explanations of the cause of accidents.

Groeneweg (1996) has specified generic error types, i.e. conditions that contribute to the creation of unsafe conditions and unsafe actions. Such generic error types are as follows:

- Design faults – inadequate design in everything from the whole organisation's physical framework to tangible aids
- Hardware faults – inadequate condition or availability of aids, tools and machines
- Procedural faults – poor quality or inadequacy in the procedures that are to be operated under
- Faults in the working conditions – poor working conditions and conditions that encourage the possibility of misunderstandings
- Order and cleanliness – in the form of mess and disorder
- Incompatible goals – health and safety cannot be maintained due to time pressures and lack of resources
- Communication – inadequate or deficient communication between the line, between departments and between colleagues
- Organisation – management and the way in which the organisation operates is inadequate
- Maintenance – deficient maintenance procedures
- Safety barriers – deficient or poor safety measures in place for risky situations

In this sense of faults occurring at several levels within the decision-making and action processes, Reason (1997) form the following explanatory model:

Figur 4

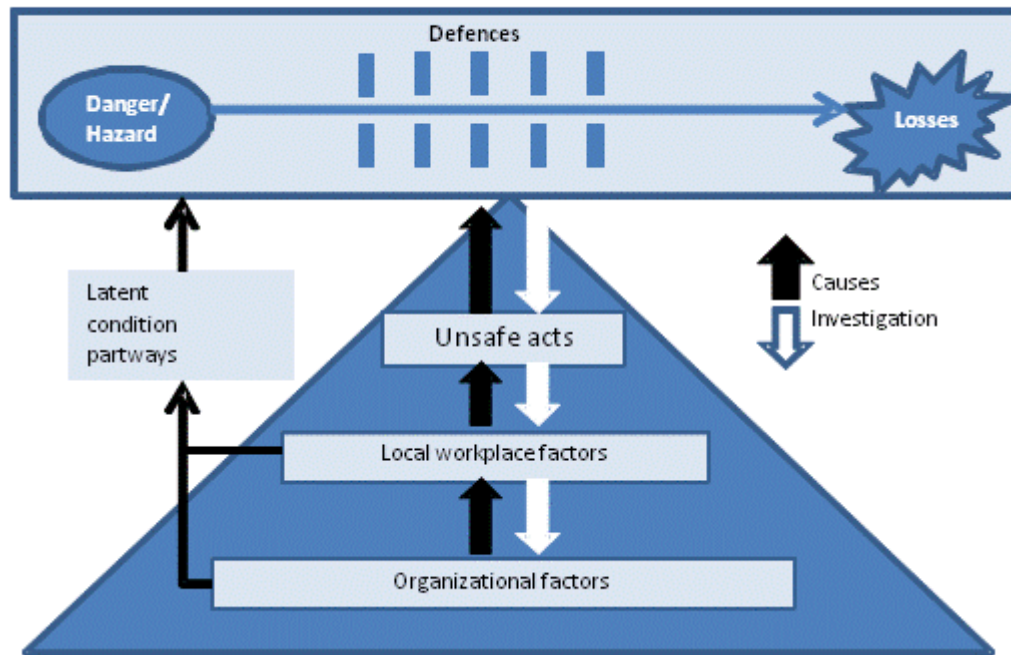


Figure 4 shows Reason's explanatory model for the causes of accidents (Reason 1997)

Where faults and actions on the basis of this can be grouped into:

1. Incorrect actions that are specific faults carried out by the individuals in the performing part at operational level
2. Malfunctions that are latent faults as a result of decisions taken by the line management, designers and planners at tactical level.
3. Source errors that are based on the decisions that have been taken by the top management, the client or the architect at strategic level.

This is further supported by Kjellen (2000), who instead talks of types of fundamental faults, types of functional faults, types of condition faults and unsafe actions.

In this way a broad perspective of faults has been provided, which explains how accidents can occur. It can be discussed whether faults are always involved or whether it is only factors that through their conditions and contexts create latent risks and thereby become part of the cause complex. We will explore this in a subsequent section.

However, there are therefore many types of mistake that can be made by many different parties, both among those who make decision and those who act. But in order not to make mistakes knowledge of the risk is required.

2.1.4 The understanding/perception of risks

"Safety must be created and recreated every day, there are no final solutions, unfortunately" (Hovden 2001)

Professor Jan Hovden's motto for the Norwegian safety days is *"the only certain thing is that nothing is certain."*, (Hovden 2001)

In a lecture on *"Our ignorance of risks"*, Jan Hovden expresses his philosophical observations of arrogance, of the belief in our own superiority, that we are able to manage

everything, can also be considered as one of the seven deadly sins in a safety-related context. Such arrogance can be and is deadly. The truth and the solution to avoiding dangers is quite simply not to be found in an area such as this, which contains so many and cross-disciplinary specialist areas, continues Jan Hovden and at the same time says that despite this must not lead to resignation, but only to a humility and continued search for more knowledge, experience and understanding of which hazards we are being exposed to and how accidents can be prevented (Hovden 2001).

The fact of the matter is that there will always be a certain risk of injury whenever we travel and what ever we do. The task is to make it possible for the individual to observe and tackle the dangers that he or she encounters and thereby prevent accidents, or at the very least minimise the probability of the accident occurring. This tasks includes three important prerequisites (Sundström-Frisk 1991):

1. The ability to recognise and know which risk is being taken.
2. The ability to know how the recognised risks can be tackled and the ability and to avoid them.
3. The willingness and desire to do what has to be done.

How great a risk can be run in a specific situation can be difficult to recognise, understand and assess and at the same time possess the necessary knowledge to act accordingly.

It is very difficult to achieve a good understanding of risks. Research has shown that a misunderstanding of the probabilities of accidents, influences from media of risk levels and misleading personal experiences often create incorrect assessments in the form of underestimating or overestimating the risk. (Lin et al 2007)

A distinction must be made between the limited risk, which is usually based on statistical data, which is often termed “objective” or “actual” risk and the experienced risk, which is a subjective assessment of the risk.

As regards the subjective risk, a distinction is made between the general subjective risk, as an expression of the generally experienced risk and the specific subjective risk, which is an expression for what an individual experiences in the situation in question . (Hovden 1984, Jørgensen 2002, Lin et al 2007)

There now follows an overview of the factors that in one way or another have an influence on the subjective risk experience divided into the factors that cause the objective risk to be underestimated and the factors that cause the objective risk to be overestimated. (Lin et al 2007)

Diagram 1

Underestimation of the objective risk	Overestimation of the objective risk
Non fatal risk	Fatal
Voluntary risk	Involuntary, compulsive
Natural risk	Industrially conditional
Scientific well-known risk	Scientific unknown or new

Well-known risk	Unknown risk
Risk that can be controlled by the individual	Risk that is controlled by others
Risk that is in the hands of a reliable source	Risk that is in the hands of an unreliable source
Risk that is dealt with responsibly	Risk that is dealt with irresponsibly
Risk where the consequences are reversible	Risk where the consequences are irreversible
Risk where the consequences are immediate	Risk with delayed effect
Risk to which children are not exposed	Risk to which children are exposed
Risk that is not unethical or immoral	Risk that is perceived as unethical and immoral
Risk that is not remembered	Risk that is remembered
Risk that is perceived as coincidental	Small risk that is expected to lead to catastrophe
Risk with little media attention	Risk that receives a lot of media attention
When the risk is perceived to be statistical, irrelevant	When the risk is perceived to be relevant

Diagram 1 shows a free translation of Lin et al's diagram for when the subjective risk experience is usually overestimated or underestimated (Lin et al 2007)

The calculated risk is usually expressed as the probability of a specific undesirable consequence occurring and can in its form appear unrealistic to the individual.

The reason for this is partly because the probability for an accident is determined by situation and party, with the influence of many visible and hidden factors at the same time as a undesirable consequence can be in "competition" with other undesirable consequences of the situation.

Where there is an undesirable consequence for a party, this can, for example, involve a desired consequence for another party. For example, when employees take the risk of quickly completing a piece of work, this usually benefits the employer or the customer (Hovden 1984).

Even those who are taking the risk will often gain from the situation, if the risk-conditional consequence otherwise fails to materialise. It is this dualism that is at play and which complicates the basis for creating prevention.

The perception of risk is influenced by a number of factors, which means that the perceived risk can be far removed from the actual objective risk.

The following are examples of factors that can influence on inappropriate perception of risk (Glendon et al 2007):

- The self-serving bias, where the individual is prepared to take the credit for successes achieved but lays the blame on other when things go wrong. This factor contributes to causes and contexts being perceived as something that lie outside of his or her area of responsibility.
- The seriousness of the consequence is of significance for who ascribed which responsibility. This comes from the idea that more serious consequences are the responsibility of the manager as this is something that must be able to be controlled, in contrast to the less serious consequences that are the responsibility of the individual.
- False agreement is when the individual believes that the perception of risk that he or she has is the same as that of everybody else and it is therefore the correct one.
- The variation in situational behaviour is underestimated, where it is believed that you can act in exactly the same way as you did before with success, without reassessing whether you are actually in the same situation.
- People give negative information a higher weighting than positive information, which is experienced in successful situations, but where a single little negative point can drown out everything else.
- The availability of “easy” explanations as to what is dangerous, which are used to simplify problems that are difficult to access. The media and press coverage can contribute to creating a general understanding that is easy to use, but which can lead to fundamentally incorrect conclusions. For example, the fact that cancer is more dangerous than asthma, even though far more many people die of asthma than of cancer.
- The representativity of what has happened before is of greater significant for an assessment of the future than an actual assessment of the future probability. For example, when the number of accidents rises, this is also interpreted as an increase in the risk and as the risk decreasing when the number of accidents falls, even if temporary fluctuations may be involved that will always be statistically present.
- Few situations can make people perceive something as being more probable than the number of situations can actually provide a basis for establishment.
- Where perceptions that were once established can be difficult to change regardless of how good evidence exists of anything to the contrary.
- Belief in knowing what is right and in believing in one’s own abilities, even if they often prove to have made the wrong assessment.
- Hindsight, where you can always see what is wrong after the accident has occurred and where expressions such as “I knew this could happen” are made, even if nobody had reacted to the risk beforehand.

Whilst the individual is able to think logically, people are not naturally logical thinkers in situations and are generally limited in their approaches to exercise any control over their surroundings. The results of this include:

- That our learning from everyday existence is not structured to develop a recognition of control

- That we use simple and often simplified models of how the world functions
- Our ability to process information is exaggerated
- That we have a limited insight into the integration methods of information
- That we are not proficient in using acquired knowledge

”Knowledge gained from our day to day learning therefore may well be incorrect”
quotation (Kreiner 2008)

In other words, safety cannot be based solely on the individual’s own assessment and own actions. There is need for training, reliable information, the systematic design of systems, detailed planning and control, expert systems in specific areas, clear auditing methods and evaluations of performance, which can in combination whole result in a better understanding of risk and therefore a better safety culture.

2.1.5 The causes and causality of occupational accidents

The anatomy of accidents is described by many diverse models. Seen on the basis of a system theoretical approach, the majority of models have common features, which Rasmussen illustrates by the following chain of events, see Figure 5 (Rasmussen 2000).

Figure 5

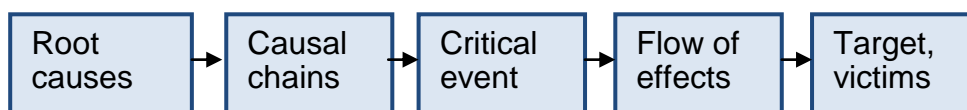


Figure 5 shows the cause – consequence chain in an accident (Rasmussen 2000)

This model must not be interpreted as if there is a simple relationship between the five elements; on the contrary, the connection from one element to the other is quite complicated. However, the model does provide a structure to this complexity by illustrating the cause chain to thereby allow different types of preventative strategies to be differentiated and targeted. Such preventative strategies could, for example, be to remove the fundamental causes, to introduce safety barriers into the chain of events, to prevent the critical event, to minimise the effect process and to consider the target/victim.

A more developed model for the anatomy of accidents is based on the attempts of thirteen different researchers to illustrate the causality of occupational accidents is shown, see Figure 6 (Jørgensen 2002):

Where the left side is the expression of the cultures, standards and values of the people who are involved and the right side if the expression of the technological opportunities that exist to examine and assess risks.

The single boxes in the model correspond to Rasmussen's five boxes and also contain the elements that a large number of other researchers have incorporated into their modulation of the causality of accidents. (Jørgensen 1982, Bird&Germain 1985, Groeneweg 1996, Andersson 1991, Raouf 1994, Koorneef & Hale 1995, Hale et al 1997, DePasquale & Geller 1999, Rasmussen & Svedlung 2000)

The boxes also constitute the decision-making hierarchy of the people who determine work conditions and work processes and therefore both risk and safety conditions.

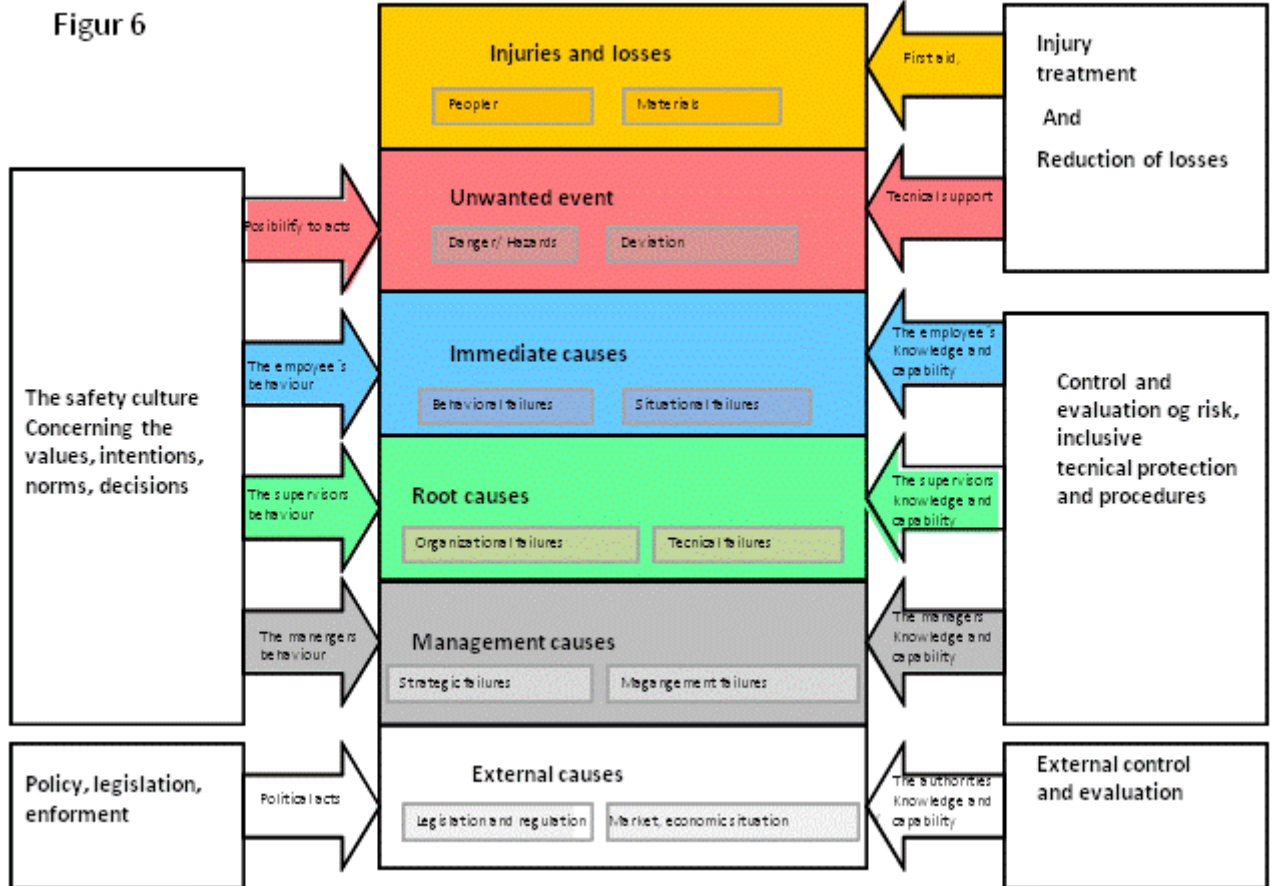


Figure 6 shows a taxonomy for causes and causality for occupational accidents (Jørgensen 2002)

Injuries and loss include all of the consequences of accidents, which concerns both the human injuries and the losses that are associated with production stoppages, destroyed materials and equipment, etc. At this level there is a certain, but absolutely limited, preventative effect, e.g. if the basis is created for the quick treatment of the injuries and other types of injury-limiting devices.

The undesirable events contain the hazards that cause the injuries and the undesirable events that result in the hazards causing the injuries. At this level it is important to be able to observe the hazards and that those who are exposed to the dangers know how to act. It is similarly important that there are built-in signals or devices that can come into effect if and when an undesirable event occurs.

The immediate causes are at operator level and will usually be the causes that are noticed when the accident occurs. At this level the accident can usually be characterised by the occurrence, either on the personnel side or the technical side, of one or other type of error that can explain the event. At this level attention will also be directed to the behaviour and actions of the personnel and also to their knowledge and abilities to discover dangers and control these appropriately.

The underlying causes lie in the organisational and technical conditions that exist, such as instruction, the layout of the work place, aids, motivation, work pressure, design, etc. and

the conditions that determine the performance of the work. Here it is the way in which the general management deals with is of great significance for how the employees act and also whether the general management has the ability and opportunity to understand what creates accidents and know what should be done.

The control-related causes lie at the more strategic level, i.e. the goals and policies that govern the development and conditions to be able to function for the whole organisation. It is here where the policies are placed, consciously or unconsciously, which create the framework for the way in which the work is performed and the conditions under which it is performed. Herein also lie the safety-related objectives, strategies and reactions that are used to manage and control at the tactical and operational level.

The external influences come from legislation and inspection practices of the authorities, but are also influenced by market mechanisms, demands by customers, conditions from suppliers, opportunities offered by technologies, etc.

Good examples of how prevention can work down through these decision-making layers are the initiatives regarding mechanical safety. EU legislation and standardisations have brought about a significant development in technical safety at the same time as the authorities have exercised a certain amount of control in this area. This has provided organisations with improved opportunities to delivery safety technical equipment, with improved technical safety measures and visual warnings, instructions, etc. This means that the very usage provides the people who are to perform the work with a significantly safer work place than before. The fact that this has been effective is clearly borne out by the statistics from the last 30 years with a continually descending curve for the number of accidents when using stationary machines.

2.1.6 The paradoxes of the risk of injury and prevention

In order to understand accidents the accidents that occur must be investigated and analysed. However, if we are to prevent accidents this must be done before the accidents occur and without knowing whether anything will happen at all. This paradox is fundamental to the prevention of accidents.

The knowledge gained from the accidents that occur can essentially only be used to learn from and to gather information on the fundamental causes that have create the basis for the accident as well as the flow of actions, events and situations that led to the accident.

A frequently used preventative strategy is one that only investigates the accidents that occur and on the basis of this ensure that there is no repeat performance. This very reactive preventative strategy has been termed “the Accident Cycle”. What usually happens is that we relax after great efforts in achieving a decrease in the accidents statistics and then after a period of time accidents start to happen again to the great frustration of those who made the efforts. This accident cycles is illustrated in Figure 7. (Krause 1995).

A better preventative strategy is, according to Figure 7, when the management takes the position that safety must be improved and therefore implements a series of campaigns and initiatives in order to achieve a low level of accidents. The initiatives are clearly driven by the management with rules, incentives, penalties and instructions. The strategy is generally top-down controlled and is based on how well we perform in relation to the demands that are placed on us. Such an initiative will usually have an effect up to a certain level. A new safety platform is created for implementation, which is measured on

the basis of the number of accidents per million working hours and is termed calculating prevention.

Figure 7

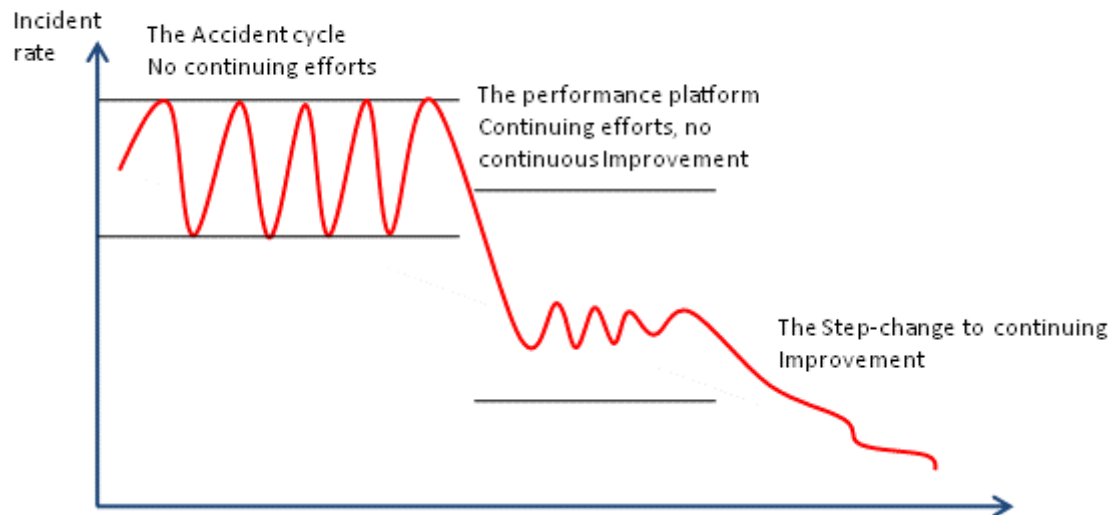


Figure 7 shows Krause's illustration of three different preventative strategies and their effect on the accident level (Krause 1995)

With this proactive prevention focus is shifted away from looking at accidents and risks to looking at safety and safety barriers. It has been initiated and supported by the management but is driven by the employees and takes place in an interaction and cooperation between the two parties. The starting point is a thorough knowledge of hazards, causes and indications that safety is not as it should be. This knowledge is coached and embedded into each employee as part of his or her professional foundation.

2.1.7 Scope of the problem

Research into accidents is predominantly based on looking at the dangers that in the event of an accident can result in extensive injuries to people and damage to the surroundings, i.e. “Major hazard”, which are completely unacceptable at a society level.

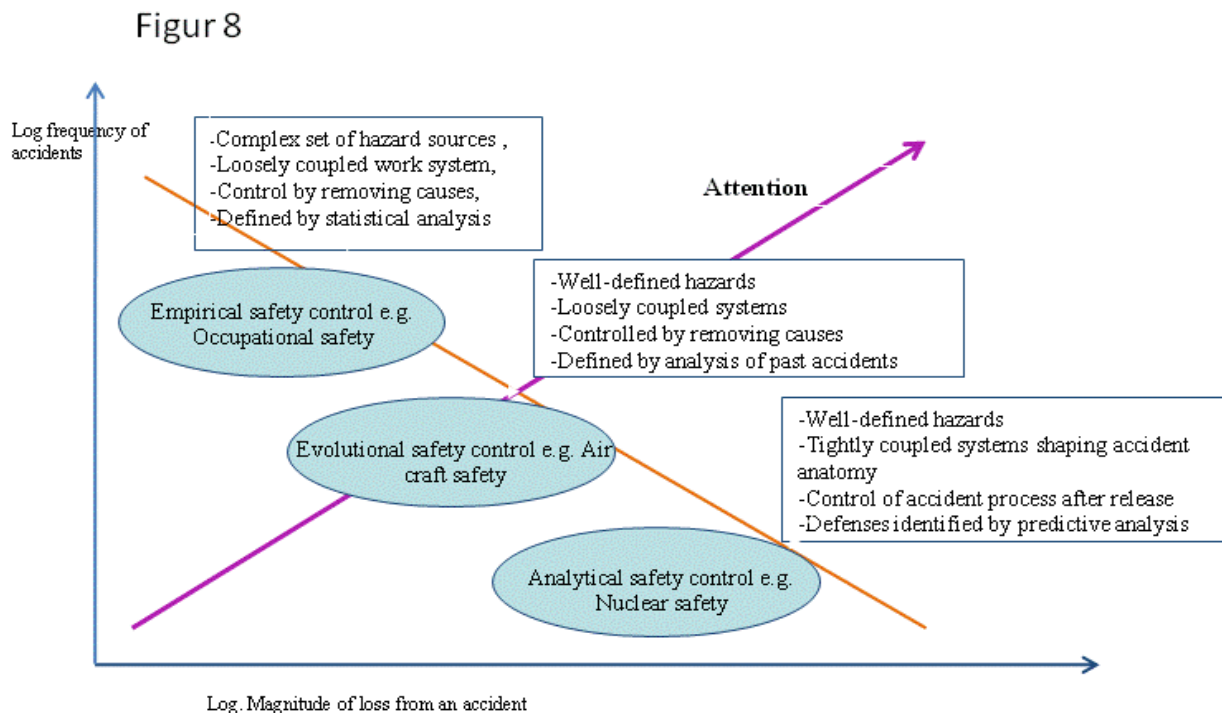


Figure 8 illustrates how different risks require different methods at the same time that they are subject to different attention (Rasmussen 1997).

The question is how far the results from this research can be used for "the more common accidents". In Figure 8 Rasmussen (1997) states the differences in the dependence of the types of accidents on the probability of the accident occurring and the consequence of the accidents.

It is though-provoking that the vast majority of serious accidents are accidents in which only a single person is injured. Therefore the number of occupational accidents globally with fatal outcomes has been estimated to be 345,000 and non-fatal occupational accidents with at least 3 days of absence from work to three billion, of which the industrialised countries account for 16,000 fatal occupational accidents and 12 million non-fatal occupational accidents with at least three days of absence from work (Takkala 1999)

2.2 Proactive prevention of occupational accidents

The proactive prevention of accidents aims to minimise the probability of accidents being able to occur.

In this section we will concentrate on a number of proactive preventative methods that focus on methods at operator level and at management level and those that can cause

these two ends to meet and fuse together in a common space that will create a long-term basis for a good safety culture.

Understanding of accidents and their causes in Section 2.1 shows that the risk of accident can be difficult to assess and predict, especially in our day to day work. However, we can use the knowledge gained from the many accidents that have occurred to create an awareness of the safety barriers that will prevent these accidents from occurring. By focusing on the safety barriers instead of the accidents we have an instrument that is observable.

The concept of safety barriers and a method for situational awareness will therefore be looked at below. Finally a method termed “message maps” will be described, these are a structured method of showing who is to observe and act on what. These three methods are important tools in proactively creating safety.

2.2.1 The concept of safety barriers

The concept of safety barriers has, as much else within the area of safety and accident research, been developed for more serious accidents, i.e. within the area of “Major Hazards”. Safety barriers are here defined as obstacles that either safeguard against (Hollnagel 1999):

- 1) an undesirable action being performed, or
- 2) an undesirable event occurring, or
- 3) that limit the damaging consequences

When an accident occurs, one or more safety barriers will have failed, either because the number of safety barriers was not sufficient, did not work as intended, or were not adapted to the situation. It is therefore essential in accident analyses to be able to identify and map the safety barriers that have failed for one reason or another.

One important reason for focusing on the safety barriers is the fact that they can be observed, controlled, initiated, secured, etc.

A distinction is made between the safety barriers that (Hollnagel 1999):

- prevent undesirable events,
- operate after an undesirable event has occurred, but which prevent injury,
- protect or limit injury when the accident has occurred.

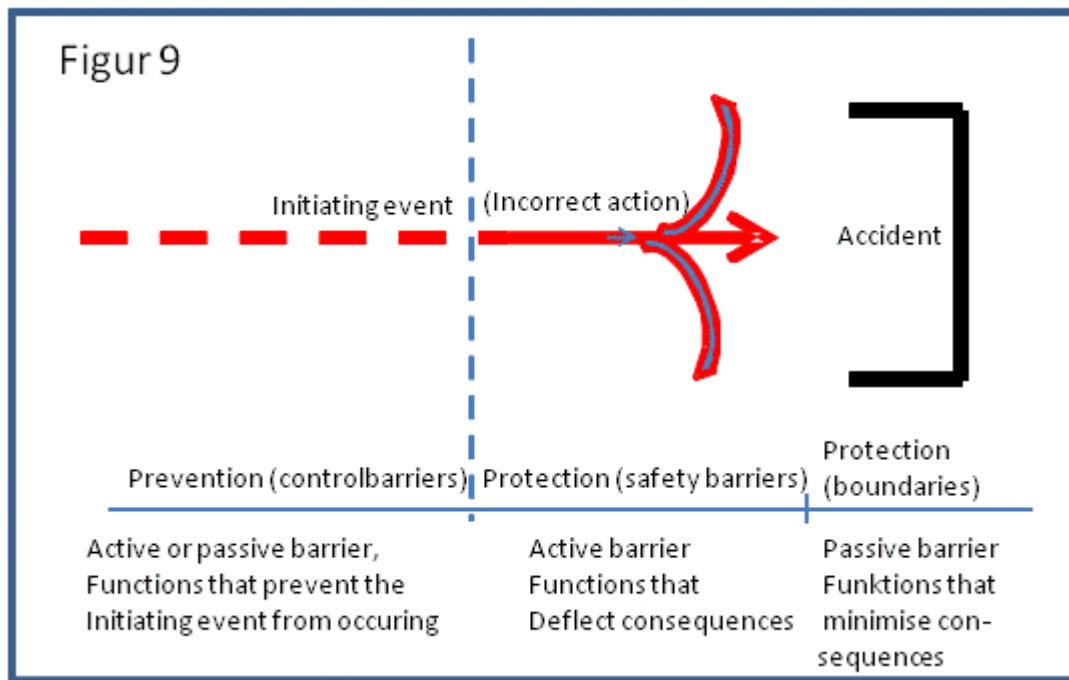


Figure 9 shows Hollnagel's illustration of the use of the barrier concept (Hollnagel 1999)

A further distinction is made between active safety barriers that require the active actions of equipment or people and passive safety barriers that function without being activated by anything or anybody externally.

An active safety barrier is, for example, an alarm that automatically stops a process or notifies the parties that they need to act in a specific way, whilst a passive safety barrier can be a set of railings, a wall or a screen that always works regardless of what is happening.

Safety barriers were originally viewed as physical safety barriers that would protect against an undesirable spread of energy being able to cause injury to people (Haddon 1973). Since that time the concept has been under discussion and there has been a development in the understanding of the safety barriers concept so that it is now described by various forms and types. This development is related to the development in preventative theories in general, which will be described below.

Taylor (1988) stipulates a number of requirements for safety barriers, which are a type of quality requirements: These are:

- that the safety barriers must be adequate, i.e. capable of preventing accidents within their function and design, satisfy requirements stipulated in standards and rules, must not be able to be exceeded by the primary system and be equipped with others that can take over if the barrier is not sufficient.
- that the safety must be accessible and stable, i.e. all signals must be able to be seen when this is necessary. The safety barriers must be failsafe and be able to be tested and be in place and be inspected.
- that the safety barriers must be robust, i.e. be able to withstand external influences and must be able to be deactivated by other safety barriers or be affected by other factors.

- that the safety barriers must not be able to lead to other types of accidents that those that they are to prevent.

Safety barriers have a number of limitation, which can be described on the basis of

- 1) how practical they are, i.e. whether they can be used and are economically feasible
- 2) how stable and maintained they are, i.e. whether they can completely or partly fail and
- 3) whether they will be used, i.e. whether they are available or they are just not appropriate to use.

Hollnagel (1999) has compiled different types of safety barriers into a classification of the functional significance of the safety barriers as inspiration in the choice of safety barriers for different types of risk.

Hollnagel acknowledges that classifying safety barriers is no simple task as they often mesh and overlap as regards function, symbolism and physical state. However, the division and categories in Diagram 2 do provide a basis for how safety barrier systems and barrier functions should be viewed.

Hollnagel has also remarked about people being safety barriers of a special type. For example, a person is able to adopt all types of safety barrier, e.g. a doorman is a physical barrier, the administrator allocating passwords is a function barrier and a policeman in the street can be viewed as a symbolic barrier for the behaviour of traffic.

Diagram 2

Barrier system	Functions of safety barriers	Examples
Material or physical safety barriers	Relimit and protect Physical obstacles that either prevent a hazard from leaving or entering a specific location.	Walls, doors, buildings, access restrictions, railings, screens, filters, containers, tanks, pipe routings, etc
	Retain and prevent movement or displacement	Safety belts, harnesses, hoarding, grilles, bolts, supports, etc
	Cohesion force , tensile strength, robustness, hardness	Components that cannot fracture in sections, e.g. fracture-proof glass
	Energy absorbent , able to absorb released energy, transmitted energy	Airbags, sprinkler systems, fire extinguishers filters, soft surfaces, etc
Function safety barriers	Prevent movement or action (mechanical, physical)	Locks, direction control, e.g. rails, coupling, synchronising, brakes, etc
	Prevent movement or action (logical, mental)	Passwords, access codes, access restrictions, advance requirements, access characters
	Hindrances or making more difficult	Distance (too low for a person to reach), maintenance (dead man's control), delays, synchronisation.

Symbolic safety barriers	Countering, impeding Interfaces that are visual or that require touching, design	Function codes consisting of colours, shapes, position, warnings, signs. Assistance with the correct action is often just as good as warnings against incorrect action
	Regulation	Instructions, procedures, precautions, conditions, dialogue
	Indications , status of system or conditions	Signals, signs, visual, auditory, movement-related, alarms, warnings
	Permissions or authorisation	Work Permits, work programmes
	Communication	Clarifications, approval, acceptance
Intangible safety barriers	Transition , supervision	Control, inspection, checklists
	Regulations	Rules, restrictions, laws, ethical standards, guidelines, prohibitions

Diagram 2 shows Safety barrier systems and safety barrier functions according to (Hollnagel 1999)

A further development of the concept of safety barriers is made by Hale & Guldenmund (2003) as a discussion paper as to how safety barriers should be used. Safety barriers are here defined as:

"the preventative measures that can both block the development of a hazard into something that is able to cause injury and the injury itself".

This sense of the concept is based on the ARAMIS project's discussion of a classification of safety barriers and the elements a barrier consists of, which are the following (Hale & Guldenmund 2003):

- A. Passive physical safety barriers (i.e. no moving mechanisms, but instead fixed objects such as walls, tanks, pipe routings, screens, etc.).
- B. Active physical safety barriers (often associated with one or other type of piece of electronic equipment, but which operates without human intervention, (e.g. automatic closing devices, sprinkler systems, airbags).
- C. Passive behavioural safety barriers (behaviour that consists of keeping away from specific areas, refraining from touching or altering specific parts of systems/materials/technologies and where these safety barriers exist without any physical involvement, e.g. safety distances, exclusion zones).
- D. Active behavioural safety barriers (where the behaviour consists of acting in specific ways and where this behaviour alone constitutes the safety barrier without any physical involvement, e.g. by performing safe working methods and following safe procedures).
- E. Combination of safety barriers A-D, where both physical and behavioural safety barriers are involved.

The delivery system that is relevant to a management team will be different for the different types of safety barriers. A particular distinction can be made between the physical safety barriers and the behavioural safety barriers.

The requirement for the physical safety barriers is that they should be decided on the basis of a risk assessment and a sufficient specification of their function and what they are to protect. The lifecycles of such safety barriers must also be looked at:

- A. Whether they were acquired and constructed in accordance with their specifications
- B. Installed correctly in the correct location
- C. Adjusted and used in accordance with the specifications within the defined area
- D. Inspected and measured to verify that they are still in good working order
- E. Maintained and repaired when they are out of order or in poor condition
- F. Adjusted as required by changes in the safety system

This purpose of this lifecycle assessment is to ensure that the barrier is available, where it is needed and adjusted and able to fulfil its function. All of these steps include people having to perform an action and display a type of behaviour that ensures that this lifecycle functions.

Behavioural safety barriers also have lifecycles, which must however be analysed in greater detail since they are dependent on different managerial functions. Seen from a lifecycle perspective, the behavioural safety barriers must be assessed in accordance with the physical safety barriers and established on the basis of a job analysis. They consist of the following steps:

- 1) Acquisition (e.g. of personnel, communications equipment),
- 2) Development (e.g. training, motivation, instruction),
- 3) Use (e.g. choice of abilities at specific times and of specific equipment),
- 4) Measurement and maintenance (e.g. through behaviour auditing and supervision).

The managerial functions that must be able to support these behavioural safety barriers have been established as follows (Hale and Guldenmund 2003):

- 1. Procedures, plans, objectives and rules that define which behaviour should be exhibited where and when, formally formulated or informally delivered to groups or individual development. The step has been designed explicitly in relation to behaviour since behavioural rules are necessary to communicate to the people they concern how, for example, the physical conditions work, how the work is designed, how systems are programmed, constructed, installed, etc.
- 2. Ensuring that people are able to behave in the desired way, including planning of workforce, recruitment policies, contracts, worksheets, timetables, plans for special tasks such as, for example, maintenance stoppages, emergency situations, etc.
- 3. Abilities and adaptation to be able to behave in the desired way, which covers physical factors such as visual range, weight, endurance as well as to knowledge, experience and learning.

4. Obligation to be aware of when a specific type of behaviour is necessary and to act in the correct manner as well as to resist all conflicting pressures that can make incorrect behaviour seem attractive.
5. Coordination and communication between people whose collective behaviour creates the barrier when they work together towards a specific goal.

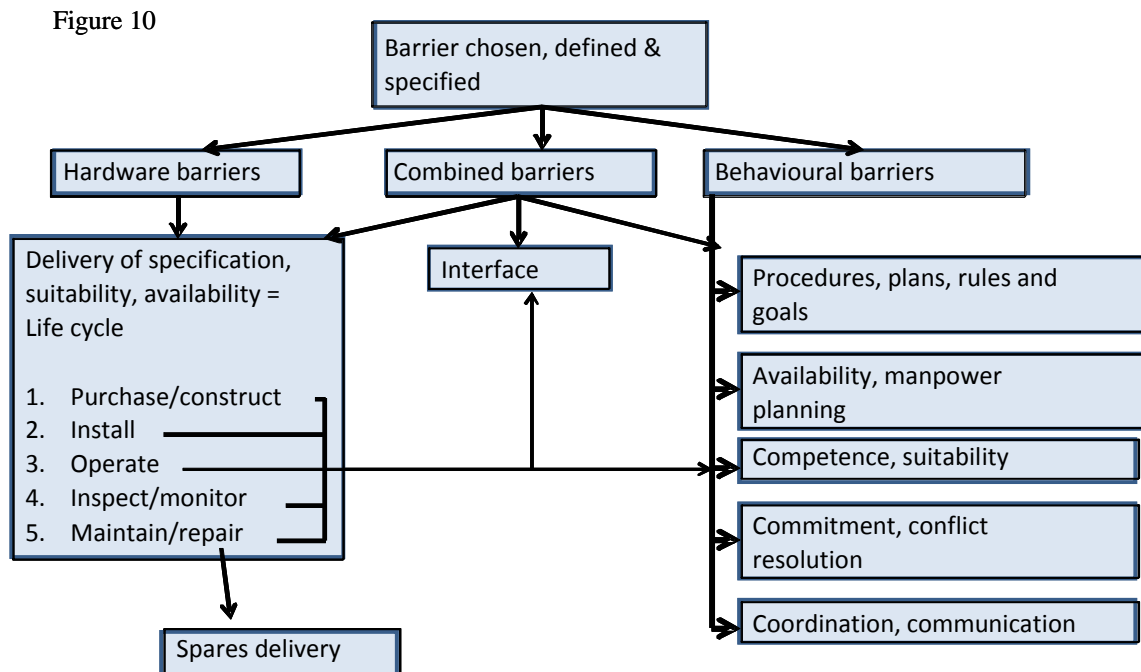


Figure 10 shows an illustration from ARAMIS of the element that safety barriers can consist of (Hale & Guldenmund 2003)

When a barrier consists of both physical and behaviour elements, this will determine managerial support for the functioning of the safety barriers. Requirement have also been made on the design of interface between the two barrier types, e.g. that they are ergonomically appropriate and user-friendly, that account has been taken of layout, that easy access has been provided, that they are easy to use, that signals are clear, that the safety barriers are well-maintained, etc.

Such an understanding of the barrier concept is therefore directly connected to safety management and thereby links the employees' behaviour and involvement in the maintenance of a high level of safety to the management's tasks to ensure that this is possible.

2.2.2 Situational Awareness

Part of the proactive prevention consists of making people aware of the risks associated with a situation at a given time and place and enabling people to observe and assess whether the relevant safety barriers are in place and in order. This has been termed "Situational Awareness", which is an important quality that people must be able to embrace in the execution of their jobs. Such situational awareness places a number of demands on the individual, his or her work conditions, the management, supervision, learning, knowledge, experience, motivation, etc. Endsley (Endsley et al 2000) has defined situational awareness as follows:

”The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future”,

A good ability to exercise situational awareness includes a language of training and experience of the signs that are important to observe and what they signify. however, with the enormous quantity of information that surrounds us in our daily lives and at work, it can be difficult to ascertain what is necessary to know and how knowledge is to be interpreted.

The following model (Figure 11) illustrates what happens in a dynamic decision-making process: (Endsley et al 2000).

Stage 1 contains the ability to perceive signs and information in the situation, this is fundamental. Without this ability the possibility of misunderstanding the current risk picture will increase significantly. Within this is the knowledge of dangers and safety barriers and the knowledge of the signals that show that something is not as it should be.

Step 2 contains the ability to understand the situation on the basis of the signs and information contributed by Step 1. This contains the ability to combine, translate, interpret, save and remember information so that it can be converted into an action. This also includes integrating the multitude of perceived information and the ability to convert this into what is relevant to the individual’s goals. A person that masters Step 2 will be able to derive the relevant activities and actions from the knowledge provided by Step 1.

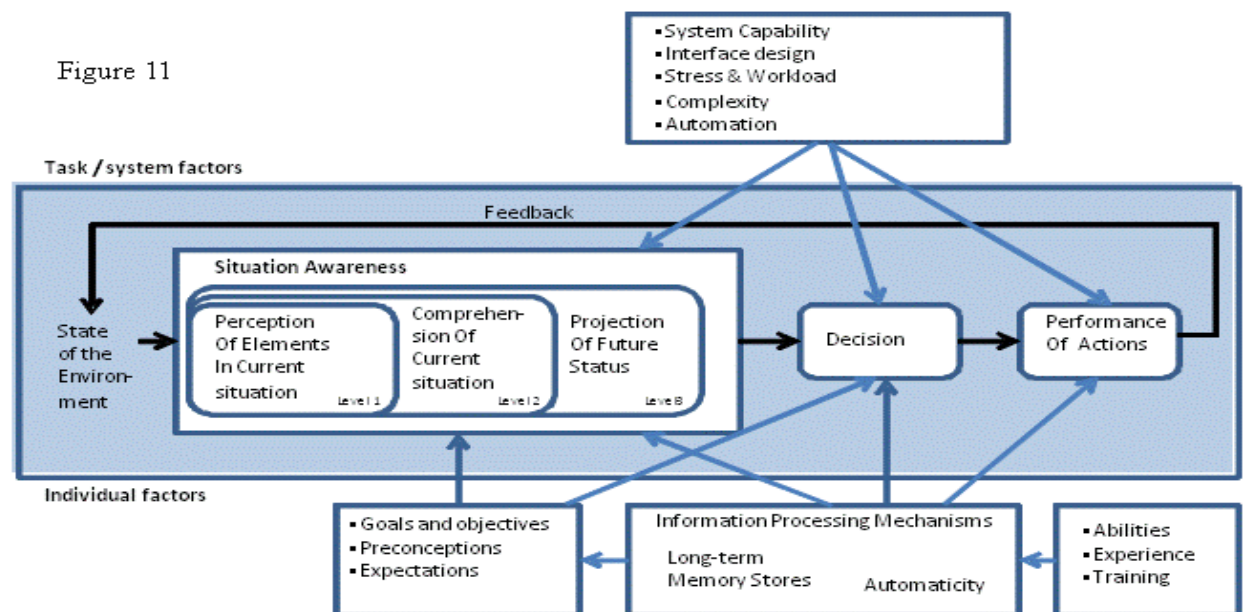


Figure 11 shows a model for situational awareness in a dynamic process (Endsley et al 2000).

Step 3 constitutes the highest level of situational awareness since it contains the ability to predict what could happen in the near or not so near future on the basis of the observation and information occasioned by the present time and the situation.

People who are capable of all three steps can be termed experienced or professional people.

A critical parameter of situational awareness is often the time that is available from the first indication that something is about to happen or is not as it should be, up to the point when an inopportune event occurs. The time aspect is therefore an important parts of Steps 2 and 3.

The dynamics of the majority of situations also mean that there is a need to understand and assess changes, to observe details and information, to convert this into an understanding and review the perception of the situation and its opportunities for the future.

Endsley also maintains that situational awareness must be viewed as being separate to decision-making and the action as he states that it is possible to have a perfect perception of a situation and still therefore reach an incorrect decision. He therefore stresses the fact that decisions are reached on the basis of situational awareness and that situational awareness is shaped by the decisions that are reached and concludes that situational awareness, decision-making and action can, in purely theoretical terms, be seen as being separate steps that influence each other in a continual cycle, but that they can become disconnected through a number of external factors.

People construct models in their minds as a way in which to understand the world. These mental constructions or models, which are also termed "Mental Models", see Figure 12, allow people to use their own premises to assess what will happen and how things will behave (Bellamy et al 2008).

Figure 12

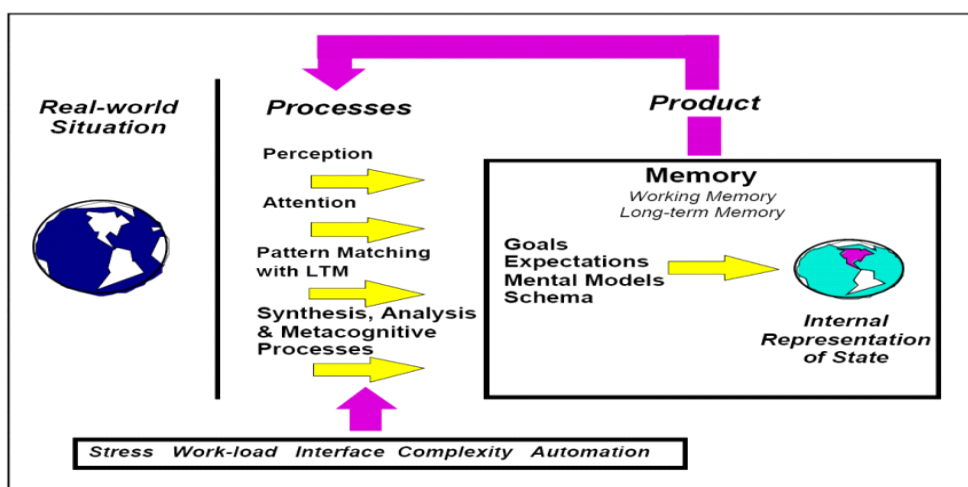


Figure 12 shows "The Mental Model" and the processes that this involves (Endsley & Garland 2000)

Endsley and Garland (2000) indicate that a number of factors influence how precisely and how completely people perceive a situation in their work environments, including the

fact that people are limited by their occupational memories and awareness. It is important to establish the way in which awareness is influenced in a complex environment with a multitude of competing factors and which aspects of situations will be used to form the situational understanding. The information that is perceived needs to be integrated with other information and compared against goals for future events at the same time as being controlled by the work-related memory bank.

Furthermore, the perception and understanding of information is prioritised by how important the individual pieces of information are perceived to be, which area again controlled by the work-related memory bank and the goals and prioritisations contained in the work.

Customs go hand in hand with mental processes, which facilitates the development of situational awareness. It has thereby demonstrated that the experiential decision-makers uses customs and traditions to recognise information of a specific type in order to understand the situation. Objectives are central to the development of situational understanding.

Fundamental is the person's processing of information within a complex system driven by the interaction between that which is data-driven and that which is driven by objectives. A person usually actively searches for the information that is necessary in order to achieve a goal at the same time as goals acting as filters in the interpretation of the information that is perceived. In addition, new data and the processing of information can indicate that new goals need to be activated.

This dynamic interchange is important in order to perform effectively in many environments.

Endsley lists a number of factors that are of significance to what a person has his or her attention drawn to and states that goals determine the direction of attention

and how situational awareness is perceived and understood. Endsley therefore concludes that if we do not understand what the objectives are of a person in a specific situation, the information within the environment will not make any sense. In addition to this, prejudices and expectations have an influence on situational awareness. People have a certain expectation of what they wish to see and hear in specific situations. These expectations influence awareness and the ability to perceive the information that is available, i.e. there is a tendency for people to see what they expect to see.

The expectations that a person has are based on his or her "Mental Model" and what he or she perceives as being significant. It is therefore appropriate to extend the person's expectations picture by, for example, instruction and training or through communication.

Finally, the automatic reaction, which has been developed through experience, can influence situational awareness. From experience, the customs awareness/ choice of action sequence will become part of the procedure that develops a certain level of automatism. This can produce good results since attention does not need to be directed towards many elements, but can be concentrated on specific tasks. But it can also be inopportune if it means that external, unexpected information will not be captured and therefore not become part of the understanding of the situation.

In reality people must act on the basis of more than the immediate information from the situation. They must be able to combine information and imagine events that extend beyond their experiences. They must be proactive and not just reactive. They must act on the basis of objectives and be able to act with a certain amount of automatic and intelligent behaviour.

When people are experienced and professional and the environment appears to be calm and routine, attention may decrease and the process of drawing conclusions that can guide decision making may become much more automatic. However, such automatism can become dangerous if the situation changes without the person noticing.

Quite a popular learning model for awareness competences are the following four competence steps, which can be used for the purpose of training, see Figure 13.

Figure 13

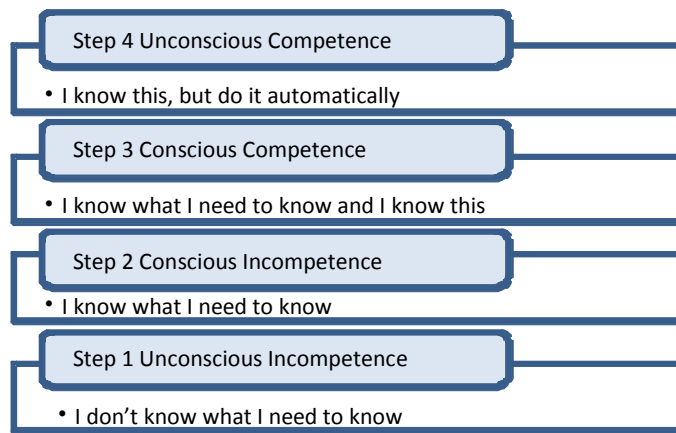


Figure 13 shows the four competence steps according to (Bellamy et al 2008)

When people unconsciously make a mistake in one way or another, this can be termed a fault, in the "Mental Model", in their understanding of the situation in which they find themselves. On the other hand, the positive aspects of human psychology can function well for people who are intelligent, are aware, have knowledge and experience and are able to compensate for poor working conditions (Sundström-Frisk 1991).

But the conditions can change in relation to what the person expects and when he or she believes that everything is going well. People do what they have learned, but without necessarily knowing that it will not work in certain situations. Therefore, when we talk of mistakes, in most situations we mean that it is what the person has learned that is incorrect and not the person in him or herself. It is important to maintain this distinction when we are to look at people's behaviour and ways in which to influence this behaviour (Bellamy et al 2008).

This has an influence on what people believe that their manager expect of them. This can mean that a person's goal for a specific task can be formulated so that it runs contrary to his or her own safety. For example, in order to complete the work faster you carry a greater weight and even rewarded with praise, rather than complete the work more slowly and safety.

Many factors can in this way threaten your opportunity and ability to reach the correct decisions, including the following (Bellamy et al 2008):

- The fact that the situation changes from being routine and involves new risks
- The fact that the situation is so routine that it leads to automatic behaviour
- The fact that the situation is perceived on the basis of incorrect objectives
- The fact that a person's capacity is limited due to:
 - An exaggerated belief in one's own memory
 - Interruptions
 - Work pressure
 - Tiredness
 - Confusion
 - Ignorance

An important element in being able to create safety is the understanding of which competences are needed in a certain situation in order to enable a person to observe, understand and act in such a manner that exposure to dangers does not lead to an accident. Lack of competence in this regard may explain why accident frequencies are higher for young people and new employees.

2.2.3 The “message maps” concept

The “message maps” concept was developed to communicate risks. The concept was developed by Vincent Covello in the early 1990s and subsequently refined by Rhona Flin. The United States Environmental Protection Agency has used the method in its instruction of Risk Communication in Action and the method has also been used by the HSE in the UK in the area of Major Hazards (Bellamy et al 2008)

The concept is constructed with a number of hierarchically structured questions that are answered in relation to customers/users, i.e. those who are exposed to dangers and who need an answer.

The principles of risk communication can be determined in conjunction with the development of these “message maps”. Message maps are an organised way of presenting important information about risks. The development of these helps to adapt the information of the most important recipients as well as to:

- Identify the most important recipients early on in the communication process
- Anticipate questions from those exposed to risks before these questions arise
- Organise thoughts and ideas and prepare messages with regards to the concerns and questions that users/those exposed to risks may have.
- Promote an open dialogue on messages and information both internally and externally in an organisation
- Create spokespeople for specific risks in a user-friendly guide
- Ensure that an organisation has consistent information and messages
- Ensure that the organisation speaks with one voice

“Message maps” is a diagram consisting of three rows and a number of boxes. In the top box are identified the users/those exposed to risks that a specific risk concerns and the question that will be addressed and answered. In the second row are formulated three key messages, which answer the overall question. From the third row and downwards is formulated the supplementary information that elaborates on the key messages. As an example, in diagram 3 is shown information on the risks of an influenza epidemic:

Diagram 3

Users – relevant recipients of the message: Primarily health care employees - the general public		
Question: What do the general public need to know about an influenza epidemic		
Key message 1	Key message 2	Key message 3
Vaccination is the top priority for:	Symptoms	Very infectious
Supplementary information 1-1	Supplementary information 2-1	Supplementary information 3-1
The elderly	Fever	Avoid direct contact with others
Supplementary information 1-2	Supplementary information 2-2	Supplementary information 3-2
Health care employees	Coughing, burning in the throat	Avoid sharing food and drinking with others
Supplementary information 1-3	Supplementary information 2-3	Supplementary information 3-3
Immune to vaccine - frail and weak people	Aching and painful muscles	Stay in bed and wash linen

Diagram 3 shows an example of a "message map" (Lin & Peteresen 2007)

After this the task is to identify the correct users and those exposed to risks and ask the correct questions. One step in the development is creating the basis for users and those exposed to risks being able to gather information themselves and understand what it means and from this able to reach the necessary decisions.

Flin et al (2006) developed a type of taxonomy for "Not-Technical Skills for Surgeons" (NOTTS), which can be used to give structure and content to the information and messages that need to be communicated. For example, this may be information on accident risks or safety barriers, cf. Diagram 4.

Diagram 4

Category	Elements
Situational awareness	Gathering information
	Understanding information
	Planning and predicting the next step
Decision-making	Assessing options
	Selecting and communicating remedies
	Implementing and assessing the decision
Communication and cooperation	Exchanging information
	Establishing common understanding
	Coordinating the group's activities
Leadership	Establish and maintain standards
	Support the group
	Able to manage tasks under pressure

Diagram 4 shows Flin's taxonomy for NOTTS (Flin et al 2006)

This taxonomy is used, among other things, to review what is understood by good and bad behaviour. The following diagrams 5-8 have been developed for accident risks.

Diagram 5

Situational awareness Here this means the development and maintenance of a dynamic awareness of the situations that a person finds him or herself in during work. The task is the gathering of data from the environment and the surroundings, understanding the significance of this information and thinking ahead as what may subsequently happen:	
Gathering of information – means actively searching for information in the work situation about the dangers that may be present or are present	
Good behaviour is: <ul style="list-style-type: none"> to look for dangers when you are travelling and assess the risk of falling to look for dangers in the surroundings and assess the risk of colliding with, being struck by, crushed between something, etc to look for dangers in manual work to assess the risk of cutting yourself, stabbing yourself, burning yourself, injury from acids, poisoned, or exposed to heavy lifting, etc to see whether any of the risks that rarely have consequences are present 	Bad behaviour is: <ul style="list-style-type: none"> being delayed and hurried without the energy to observe and assess risks to begin the task without any type of observation or considerations of the circumstances to carry out your own work without considering the influences or impact it may have on the surroundings and other people's situations to forget to check special instructions to ignore instructions from colleagues and the general manager or signs
Understand information – means that your mental image of the conditions is updated by interpreting the gathered information and comparing this information with your own existing knowledge of the situation in relation to the expected situation	
Good behaviour is: <ul style="list-style-type: none"> acting on the basis of observations directing questions to relevant people if there is information that you are not sure about to forward observations to colleagues and the general manager 	Bad behaviour is: <ul style="list-style-type: none"> ignoring information about risk factors disregarding important signals misunderstanding the signals and thereby acting inappropriately to take chances because this is easier
Planning and predicting the next step – means predicting what may happen in the near future as a result of possible actions or if no action is taken	
Good behaviour is: <ul style="list-style-type: none"> planning the tasks that must be performed on the basis of the knowledge that has been gathered to consider and obtain the equipment that is to be used to communicate considerations and decisions with the relevant parties 	Bad behaviour is: <ul style="list-style-type: none"> continuing to work without considering what could go wrong failing to discuss potential problems with other parties acting far outside your own area of experience

Diagram 5 shows examples of good and bad behaviour in relation to the subject of situational awareness

Diagram 6

Decision-making	
Experiences of diagnosing situations and reaching an assessment for the purpose of deciding upon an appropriate way in which to act	
Assessing options – means being able to generate alternatives or directions in which to act in order to complete the task. Assessing risks and considering threats and advantages and the possible courses of action	
Good behaviour is: <ul style="list-style-type: none"> • recognising and articulating the problems • initiating a balanced discussion of the options for and against with the relevant parties • to ask colleagues their opinions and for solutions • to look for any written instructions 	Bad behaviour is: <ul style="list-style-type: none"> • failing to discuss options • failing to gather opinions from other parties • ignoring written instructions
Choosing and communicating remedies – means choosing a solution to the problem and making all relevant parties aware of the chosen remedy	
Good behaviour is: <ul style="list-style-type: none"> • reaching a decision and communicating the decision • to devise a plan B and also communicate this plan • to explain why the chosen solution has been decided on 	Bad behaviour is: <ul style="list-style-type: none"> • forgetting to inform others what you intend to do • being aggressive if a plan is questioned • to close a discussion about other solutions • only doing what he or she believes is what needs to be done • choosing an inappropriate solution that leads to complications
Implementing and assessing the decision – means setting about performing the solution on the basis of what has been decided and continually assessing its suitability in the light of the circumstances and working conditions. Demonstrating flexibility and ability to change the plans should this prove to be necessary in order to achieve the desired goal.	
Good behaviour is: <ul style="list-style-type: none"> • implementing the decision • updating all those involved during the course of the implementation • reassessing the plan in the light of changes or if problems arise • acknowledging of plan A is not working and then moving over to plan B • calling for assistance if there proves to be a need for this 	Bad behaviour is: <ul style="list-style-type: none"> • failing to implement the decision • repeating the same mistakes several times • failing to reassess the chosen solution • continuing with plan A even if a alternative course of action would be better • being rash or hasty in order to meet a tight schedule.

Diagram 6 shows examples of good and bad behaviour in relation to the subject of decision-making

Diagram 7

Communication and cooperation Experience in working in groups and ensuring that everybody in the group has an acceptable shared view of the situation that means that they are able to perform the task efficiently and safely	
Exchange of information – means giving and receiving knowledge and information at the right time in order to create a shared understanding amongst the members of the group.	
Good behaviour is: <ul style="list-style-type: none"> • talking about how the task is developing • listening to concerns within the group • communicating should the plans change 	Bad behaviour is: <ul style="list-style-type: none"> • forgetting to communicate concerns to others • attempting to resolve problems alone • failing to listen to the group • failing to explain what is expected of any assistance should this be needed
Establishing a shared understanding – means ensuring that the group does not only have the necessary information but also understands what it means and accepts what the situation is, the task includes and what is to be done by each member of the group.	
Good behaviour is: <ul style="list-style-type: none"> • briefing and clearing up facts and goals before the group starts on the task • ensuring that the whole group understands the operational plan before starting • to receive questions and points of view from all those in the group • ensuring that everybody in the group is comfortable with the decision • checking that any assistance in what the task is about • debriefing the group after the task has been completed in order to learn from what went well and what gave problems 	Bad behaviour is: <ul style="list-style-type: none"> • failing to discuss the plan with the group • failing to devote time to a collective dialogue and assessment • forgetting to discuss the matter in advance with new members of the group • failing to try to discuss problems that arise during implementation • showing dislike in subsequently discussing actions, decisions and implementation should somebody ask questions
Coordinating group activities – means that you must cooperate with other group members in order to perform the knowledge-based and physical activities in an appropriate and coordinated manner.	
Good behaviour is: <ul style="list-style-type: none"> • checking that the others in the group are ready to start the task • to stop performing the task should other in the group experience problems • ensuring that the group works efficiently at organising the activities in a timely manner 	Bad behaviour is: <ul style="list-style-type: none"> • failing to wait until everybody is ready • to continue with the task without ensuring that all equipment is available and ready for use • continuing the task yourself if there are others in the group who are experiencing problems

Diagram 7 shows examples of good and bad behaviour in relation to the subject of communication and cooperation

Diagram 8

Leadership Leading a team and indicating the direction in which the work is to be performed as well as demonstrating a high level of safe working practices and at the same time being aware of what each member in the group requires with regards to knowledge and guidance	
Set and maintain standards - means providing a safety and quality-based maintenance of the principles for the performance of the work through the application of good and safe working practices and following the applicable rules and procedures	
Good behaviour is: <ul style="list-style-type: none"> • introducing yourself and the standards to the group and in particular to new members • setting a clear standard for following rules and procedures • requiring that all members of the group observe the standards that have been set 	Bad behaviour is: <ul style="list-style-type: none"> • forgetting to observe whether standards are being observed • breaching the stipulated standards and rules yourself • showing a lack of respect for the task and its performance
Supporting the group – means providing both knowledge-based and emotional assistance to members of the group. Assessing the abilities of the various members and adapting the management style accordingly.	
Good behaviour is: <ul style="list-style-type: none"> • adapting your behaviour according to the training needs of the individual • conducting constructive criticism of each group member • ensuring that the assignment of tasks is appropriate • giving praise and rewards for work that has been well-done 	Bad behaviour is: <ul style="list-style-type: none"> • failing to notice work that has been well-done • forgetting to be attentive to the needs of others • only looking at your own narrow resolution of the task looking at what tasks and options others have • demonstrating hostile behaviour towards individuals, e.g. through sarcasm, irony, etc
Accomplish tasks under pressure – means demonstrating calm behaviour in stressful situations and emphasising to the group that you have control over things. Adopting a suitable forceful attitude if necessary without undermining the roles of other group members.	
Good behaviour is: <ul style="list-style-type: none"> • remaining calm under pressure • highlighting what is important in the situation possibly by raising your voice • taking responsibility for critical situations • taking the necessary decisions under pressure • delegating tasks so that the task may be resolved • continuing to lead the group through crisis 	Bad behaviour is: <ul style="list-style-type: none"> • stifling concerns about problems • demonstrating a lack of ability to reach decisions under pressure • failing in leadership when, for example, technical equipment requires your full attention • blaming everybody else for mistakes and failing to take any personal responsibility • losing your cool, getting angry and scolding

Diagram 8 shows examples of good and bad behaviour in relation to the subject of leadership

This system and mindset has been devised to be used in the training of inexperienced people as a basis for being able to structure observations and for assessing and providing feedback in a training situation.

The various models that are presented for the safety barrier concept, mental mind, situational awareness and message maps have been combined by Bellamy et al (2009) to form a special type of message maps with a focus on safety barriers to accidents. The method has been termed “Barrier Intelligence”.

The purpose of this type of “message maps” is to develop a basis for instruction and training. Focus is on the information that is to be observed in relation to safety barriers and dangers and which can provide the best basis for decision-making and the subsequent actions. Bellamy’s illustration of how she combines the various models is shown in Figure 14.

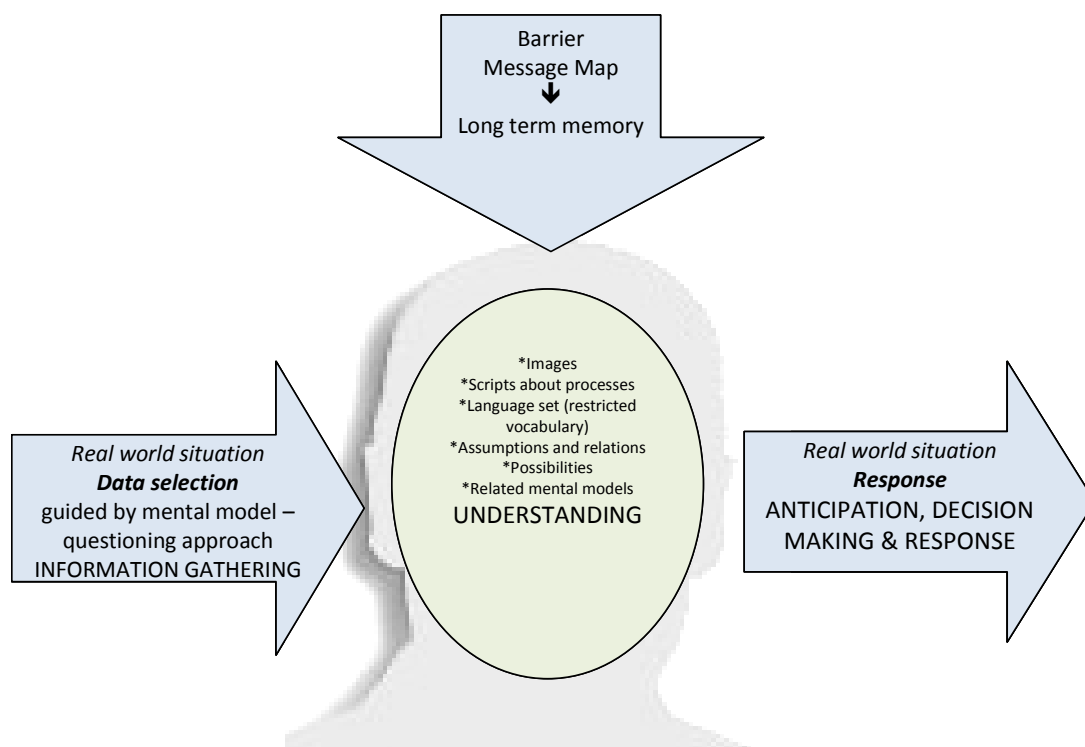


Figure 14 shows Bellamy’s illustration of knowledge-ability-action in relation to safety barriers and “message maps”, etc. (Bellamy et al 2009)

This summary is subsequently expressed in the design of targeted “message maps” for specific types of dangers and safety barriers. These can be used in training situations and feedback systems to create situational awareness and enhanced safety competences.

Diagram 9 contains an example of the design of a simple “message map” in which the risk relates to “Being struck by a moving object” and where the safety barrier is to ensure control over the moving objects that may be in the immediate surroundings of a specific person.

Diagram 9

Risk: Being struck by a moving object Safety barriers: Control over moving objects in the immediate surroundings		
Gathering information	Understanding information	Prediction and reaction
Where there are moving objects in the vicinity	Assess whether the movements can result in their striking you	Securing moving objects and their movement paths
The way in which they move	Assess whether the movements vary and whether there is any need for adjustments	Adjust, signal, note, communicate with the surroundings
Can their movement get out of control	Assess what can lead to the movements getting out of control	Check safety devices and information to the surroundings
Can I enter into the movement path of the object	Assess what type of behaviour I should demonstrate in order not to enter into the movement path of the object	Adapt your own behaviour

Diagram 9 shows an example of a "message map" for the risk "being struck by a moving object"

It is clear that this diagram could contain much more specific information if we were to choose to specify, for example, "being struck by a truck" or "being struck by a machine part", which would also mean that the information in the diagram could be made significantly more specific and targeted.

The more specific we are in specifying a job and the type of risk and safety barriers the more specifically we will be able to specify what is to be observed, how the information is to be understood and how dangerous situations can thereby be predicted and countered.

The concept is also not solely directed at employees, but can equally be used with regards to general managers, middle managers and top management, obviously with adapted content.

2.3 Management concepts and control methods

The development in preventative theories through the years has evolved into a number of phases where the conclusion is that prevention cannot be created using a theory or a method, the perspective for this is far too complicated. On the other hand, there is use for creating an understanding for the various elements of accident prevention and to combine different methods and initiatives.

We speak of orchestrating prevention, i.e. cause many different initiatives to interplay (Lund and Aarø 2004).

Over the course of many years the prevention of occupational accidents and the aspect of safety has been associated with a technical prevention, which has led to dramatic

improvements in machinery and equipment as well as a large number of technical instructions, rules and procedures.

Between 1970 and 2000 focus was moved toward the management aspect of safety and people's behaviour and behavioural control. This occurred in particular within high-risk areas in which research and focus on risks has been greatest, just as the majority of experiences have been created based on large international groups. (Hale & Hovden 1998)

In this context, there are a number of results from companies that have shown that they are able to achieve a high level of safety. These include the following: (Glendon et al 2007, Hovden 2001, Herrero et al 2002, Kjellen 2000)

- That safety begins with the top management
- That the most important improvements require changes to the managerial culture
- That a long-term commitment to safety from the top management is necessary to create change
- That it is not enough for the top executive to state that he or she supports a high level of safety. He or she must also demonstrate this through his or her behaviour, actions and leadership. He or she cannot delegate this part.
- That safety will not result solely from checks and inspections, but primarily through developing and improving processes
- That the top management has a tendency to make employees responsible for conditions over which they have no control. People work in the system that the top executives create, he or she is therefore the only one who is able to change it.

It is pointed out again and again that safety must be integrated into the whole organisation and function at all levels of management, just as it must involve all of the employees in their day to day work. Similarly, the importance of emphasising training in safety, good communication, good order and a stable workforce is repeated. (Cohen et al 1975, Smith et al 1978, Glendon et al 2007, Kjellen 2000).

Finally, the role that both the top executive and the general managers have in creating a good level of safety within the organisation is highlighted in repeated studies (DePasquale and Geller 1999, Glendon et al 2007, Kjellen 2000).

Proactive prevention is also about process and organisation, where the manager has a major importance, including his or her ability to involve both middle managers and employees in the safety work. The understanding of the concept of safety culture and in particular the methods of creating a good safety culture therefore naturally follow in the order of methods to achieve a high level of safety.

2.3.1 Strategic, tactical and operational management

The guidance of both the top management and the general managers has both a direct and indirect significance on the behaviour of the employees. The direct behaviour relates to the establishment of standards for working practices and procedures for the performance of the work.

The direct effect relates to the management's perception of safe and unsafe behaviour and their influence on the behaviour of the employees through observation and monitoring. The management's actions influence both directly and indirectly the expectations and

motivation of the employees and thereby also influence the probability of specific types of behaviour being repeated or suppressed. (Flin and Yule 2004).

In some of the publications of recent years the significance of management and styles of management to safety has been looked at including the difference between transformational (agreement) and transactional (change) management inspired by Bass 1985. (Glendon 2007, Flin and Yule 2004)

Where transactional management is characterised by:

- Honouring good work and results with rewards
- Meeting problems halfway and then acting by measuring the behaviour of the employees
- Focusing on and correcting mistakes made by employees when problems arise

Whilst transformational management is characterised by:

- The manager showing interest in the professional development of the employees and acting as a type of monitor as well as being attentive to needs.
- The manager meets challenges, takes a certain amount of risk and attempts to follow employees' ideas, stimulate and encourage them to be creative and innovative
- The manager inspires others towards achieving goals and creates meaning, optimism, enthusiasm and articulates visions that appeal to and inspire others.
- The managers creates trust and is perceived as being charismatic, behaves in ways that allow the employees to identify with him or her.

Glendon et al 2007 mention a number of researchers who have placed transformational management into a context with low accident frequency in the organisation.

Leadership and safety management must function at all levels within a management structure. For example, this can be illustrated by what is to take place at the strategic level, i.e. by the top management, at the tactical level, i.e. by the middle managers and at the operational level, i.e. by the general management, supervisors, team leaders, etc. In Diagram 10 Flin and Yule (2004) give their understanding of the styles of management and the way that safety management at the three management levels can be characterised.

Traditional safety management with a active and professional safety manager who controls and monitors the employees' compliance with the organisation's safety-related

standards and procedures. They are familiar with the rules and regulations and the information about new regulations, conduct inspections and audits, take charge of the investigation and analysis of accidents and put forward recommendations for future accident prevention. (Herrero et al 2002). Traditionally, professional safety managers adapt the employees' behaviour through motivational activities, e.g. incentives, prizes, etc. (Smith 1996)

This style has a positive effect on safety up to a certain level, but this does not always mean that safety is appreciably improved, especially if focus is primarily placed on the technical equipment and the short-term results and if action is only taken when an accident occurs.

Another limitation of the traditional safety system is that safety measures are isolated from other functions within the organisation. Responsibility for the safety programme is placed with the safety manager, who has a position within the company that in many cases does not give him or her the authority to create change.

Diagram 10

Safety management	Transactional management (agreement management)	Transformational management (change management)
General management – the operational level	<ul style="list-style-type: none"> - Observe and enhance the employees' behaviour with regards to safety - Participate in the employees activities with regards to safety - Perform the activities that have been established at tactical level 	<ul style="list-style-type: none"> - Support initiatives with regards to safety - Motivate and encourage the employees to take initiatives with regards to safety
Middle management – the tactical level	<ul style="list-style-type: none"> - Involved in activities with regards to safety - Observe and enhance the general management in its behaviour with regards to safety - Establish frameworks and methods for the implementation of the vision 	<ul style="list-style-type: none"> - Emphasis safety taking precedence over productivity - Emphasis a decentralised management style - Provide a cooperative vision of safety in relation to the general management
The top management – the strategic level	<ul style="list-style-type: none"> - Ensure compliance with legal requirements - Allocate resources for a comprehensive safety programme - Establish the company's vision for future safety within the organisation 	<ul style="list-style-type: none"> - Demonstrate a visible and enduring commitment to safety - Show care and concern for the employees - Encourage a participative management style amongst the middle managers and the general management - Allow time for safety

Diagram 10 shows Flin and Yule's understanding of the relationships between management style and management level with regards to safety (Flin and Yule 2004).

Canadian studies also show that in the organisations that are able to demonstrate a high level of safety, safety is not seen as a separate problem, but on the contrary as an integral part of production, competition and profitability. It is not immediately apparent that safety and profit are incompatible goals, but are rather complementary since they share the same driving forces where integration is the key (Warrack 1999).

The general management

The foreman, the team leader or the supervisor, i.e. the general manager is the key person in the prevention of occupational accidents. His or her understanding of the art of guiding

and controlling the employees' activities is the most important factor in successful accident prevention (Heinrich 1959).

The immediate manager of employees has the primary responsibility for ensuring that the work is completed. He or she structures, coordinates and facilitates the work-related activities. (Flin and Yule 2004)

It has been shown, among other things, that when the general manager talks more about work-related matters with his or her staff and this is supported by activities, the safe behaviour of the employees increases (Zohar 2003).

Other studies substantiate that general management involvement in safety has a positive effect on the behaviour of employees (Barling et al 2002).

Including the extent to which the general manager is able to communicate and initiate discussions regarding safety with his or her staff and how he or she is able to support the staff in relation to the work tasks and provide them with positive feedback. (Mattila et al 1994, Simard et al 1994).

It has also been demonstrated that the employees work more safely when they have been involved in the decisions regarding how the work is to be performed, when they have a specific and appropriate responsibility for their own tasks, when there is purpose and authority behind the tasks and when they are provided with immediate feedback to their work. (Cohen and Cleveland 1983)

In organisations with high levels of safety the general manager assists in a number of activities: (Simard et al 1994)

- they allow the safety staff to spend a large proportion of their time on safety-related matters
- they involve themselves together with the staff and other managers in the development of safety procedures and programmes
- they involve themselves together with the staff in safety inspections of the work places and in the investigation of any accidents
- they take responsibility for training new members of staff in safety

Tactical management, middle managers

The middle managers have received less scrutiny in safety research, but there is a lot of evidence that they are of vital importance to the level of safety within an organisation (Flin and Yule 2004).

Studies show, among other things, that the safest organisations have middle managers who are able to demonstrate that they are committed to safety and the organisation's safety systems and that they involve themselves in safety-related activities. Their management style therefore influences the safety-related results. It has also been shown that the middle management of organisations with high levels of safety often have a close working relationship with the staff and one-to-one safety meetings, whilst organisations with lower levels of safety are characterised by their middle managers fully surrendering safety issues to the safety organisation (O'Dea and Flin 2003, Smith et al 1978, Kivimaki et al 1995).

It is often said that the middle management is the mineral wool layer between the top management's vision of safety and the ability to bring this vision out into the operational level, i.e. the middle management is a wheel chock for the process in the management chain. This has not been immediately demonstrated in research, but is an often expressed understanding. (Flin and Yule 2004).

Strategic management, the top management

In larger organisation it is not uncommon for top management to be geographically located in a different location to the actual organisation. Their responsibility is on the strategic level and is focused on long-term planning. However, they have the ultimate responsibility for the organisation's level of safety. (Flin and Yule 2004)

The top management is able to demonstrate its commitment to and prioritisation of safety through a number of strategic initiatives, such as providing resources for an extended safety programme, by showing care and concern for the employees, by showing involvement and commitment towards the middle management and the general managers and by being clear and consistent in their support of and focus on safety, which includes exhibiting a transformational management style. (Flin and Yule 2004, Simard et al 1994, Cohen and Cleveland 1983)

Decisions reached by the top management have an influence on the prioritisations, attitudes and behaviour of both managers and employees further down in the hierarchy, which are critical factors that are of significance to the general manager's choice and balancing between safety and productivity in the daily work.

One of the findings of a study of the significance of top management to safety included a number of facts relating to the behaviour of top management. (Flin and Yule 2004, Smallman 2001)

These include the ability to:

- be able to articulate an achievable vision for future safety performance
- to demonstrate personal commitment to safety of a symbolic type
- to be able to engage everybody with relevant experience of making decisions within the subject of safety
- to be clear and transparent with regards to safety-related matters

2.3.2 Objective and feedback as indicators

Objective and feedback are indicated as being effective means of creating altered types of behaviour and attitudes (Smith et al 1978, Zohar et al 1980, Saari 1989, 1994). The basis for this is a method to motivate and learn. The philosophy is that we are motivated partly through the reward that is achievable and partly through the joy achieved by an individual in having influence and satisfaction in a job well done (Glendon et al 2007).

One example of a successful programme includes (Cooper et al 1994):

- A list of critical types of behaviour was drawn up for a department based on an analysis of accidents.
- Observers were recruited and trained to observe how and when the critical types of behaviour were being exhibited.

- A four-week observation period was used to establish the level that would be the basis for an initiative.
- Objectives meetings were held between all of the employees and managers including the top management. During these meetings agreement was reached at all levels as to the future goal and what could be committed to in an improvement process for both management and employees.
- A sixteen week intervention period followed with weekly feedback on how good the individual units were in fulfilling the goals that everybody had agreed. This feedback was presented on posters where everybody within the organisation could see how things were going and who had performed well and who had performed less well.

The result was that a 70 % improvement could be observed in types of behaviour in the critical areas at the same time as the number of accidents had fallen by over 20 %.

In order to achieve success in such a programme, an important element is the way in which the employees are involved in the programme and the extent to which the employees believe in the management's intentions and have faith in its ability to implement the programme and maintain it. This is best done when management at all levels are included in the process and clearly supports the process in its allocation of time and resources. (Glendon et al 2007, DePasquale and Geller 1999).

A frequently used method to create awareness of safety and to motivate towards safe behaviour amongst the employees is through one or other type of incentive such as prizes or rewards. Where this has taken place in an appropriate manner, i.e. where the reward is made, for example, on the basis of specific rules being observed or specific types of behaviour exhibited, good effects are achieved (Glendon et al 2007, DeJoy 2005, Krause et al 1999, Lund and Aarø 2004).

However, it is also pointed out that short-term initiatives often have short-term effects, meaning that when focus disappears from a specific subject, the behaviour also disappears and safety is thereby back at the same level as before. It is therefore not sufficient to change a type of behaviour without also changing attitudes and positions, which can ensure that the new behaviour will be learned so well that it will also become a good habit.

That, as studies show, which has a such a confidence-building effect on the employees includes (Cox et al 2004):

- When the managerial culture is that safety is a first priority and when the management shows its commitment to safety during the implementation of the programme.
- When effective motivating methods are employed, including employees receiving praise when they work in a safe manner.
- When greater opportunity for individual learning is provided and by enhancing the joy and usefulness the employees experience in exhibiting the desire behaviour and achieving the safety-related results.
- When there is greater opportunity for organisational learning through communication and knowledge-sharing between the employees and when there is greater awareness of safety and work place values.

In many respects it is a change management task to implement a safety programme within an organisation with the objective of changing awareness and behaviour in relation to risks and safety barriers.

2.3.3 Changing safety

It is when accidents occur or increase in extent and when in some other way a lack of awareness is registered toward hazards that the management become aware that a change must occur. However, it is not uncommon for people to sort of live with the accident level that is present as if it could not be different.

However, the methods behind change management can be of great significance where change is really wanted. A review of the theories behind change management will not be given, but only a fundamental methodic understanding will be presented, which can be the inspiration to a method for changing the level of safety.

In their book on change management, Kamp et al (2005) describe the dynamics of change by means of three sub-processes strongly inspired by Patrick Dawson (2003). This takes place through a learning process, a political process and a symbolic process:

"The learning process is seen as a condensed form of knowledge, a learning opportunity that forms the basis for learning within the organisation. The learning process facilitates a flexible adaptation to new requirements. Focus is on who the organisation (the inner context) acts as a learning environment, on the opportunities and obstacles to reflection posed by the learning. The employees and managers' changes, their assimilation of new competences and altered view of goals, resources and relationships are vital for the organisation to be able to learn. Broad local involvement and ownership are therefore keywords in the learning process."

"The political process is seen as a political programme that does not neutrally offer the organisation adaptation to new requirements, but which has a built-in preference structure, a specific way in which to view the future of the organisation in which specific managers and employees to some extent have a privileged role in the change process. The programme is carried forward by a coalition of participants within the organisation. Focus is placed on how this programme is negotiated in an attempt at extending and retaining its legitimacy and to create support within the organisation. The context is a negotiated order that has with time become natural, but which will be renegotiated during the change process."

"The symbolic process is seen as the carrier of symbolic meanings. The concept often forms the fashion as the symbol for the new and to appear to be a modern organisation. This is of significance for internal and external branding. The symbolic process provide the employees within the organisation with a new language and in this way allows them to create image and status when they acquire "modern" logic. From a symbolic perspective, the change project can to a certain extent be window dressing and primarily serve to enhance the organisation's identity and image. However, symbols can also create changes within the organisation when new symbols are incorporated into the existing narratives and transform them, which has an effect on the universe of myths, stories and rituals."

This structuring of the change process is believed to be appropriate in relation to the question of creating a change to safety, where it is absolutely necessary to focus on methods, content and participants.

2.3.4 Safety culture and safety climate

Creating a high level of safety within an organisation is a difficult undertaking, which largely requires managerial involvement and constant focus. This is not only a question of having the correct equipment, procedures or safety organisation, etc., but also that everybody within the organisation has an understanding for safety and for committing themselves to take responsibility for safety in all endeavours and at all times.

It became particularly apparent from the major nuclear power accidents of the 1980's where the investigations showed that the formal conditions were in order, but that the management and employees did not have a constant focus on safety. This became a question of attitudes and behaviour and since that time there has been a significant focus on topics such as safety culture and safety climate.

The literature contain a diverging perception of what safety culture and safety climate cover, but generally a picture is drawn of safety culture being an expression of the standards and values of the individual in relation to safety, whilst safety climate is an expression of the organisation's generally expressed standards and values that are often demonstrated through measurements and questionnaires and with a focus on the managements and its ability to disseminate these standards and have them accepted within the organisation.

Nor will a review of safety culture theories and methods be given here, instead some of the most important elements that create a good safety culture will be stated.

For example, Reason (1997) points out three significant factors (the 3 Cs) for a good safety culture. These are:

- Commitment – i.e. a commitment with regards to safety that is able to both motivate and secure the necessary resources, etc.
- Competence – i.e. to gather the correct information and train, practice, etc. so that the correct action can be taken.
- Cognization – i.e. to be aware of the hazards, risks and safety barriers that are completely necessary elements in maintaining safety.

Means et al (2003) points to another three themes as being important for success in the area of safety. These are:

- A genuine and continued management commitment to safety, i.e. prioritising safety over production, a sustained high profile at safety meetings, personal participation of the managers at safety meetings and in inspection rounds, face-to-face meetings with the employees with safety as the topic and implemented job descriptions that contain a type of safety contract.
- Communication of safety topics, i.e. a widely-extended and pervading channel of formal and informal communication and regular meetings about safety matters between the top management, middle management, the general management and the employees..
- Involvement of the employees, i.e. allowing the employees to attend to safety, responsibility for safety is delegated and the employees are encouraged to commit themselves to the organisation's safety level target.

The top management has the primary influence on an organisation's safety culture where it needs to constantly demonstrate the very best visible commitment to safety for the time that it spends on safety-related issues (Flin and Yule 2004).

A method to differentiate between different safety cultures includes the one used by Shell illustrated in Figure 15. It is based on a five stage scale comprising confidence in the management, its responsibility and ability to inform and communicate aspects of safety.

Five stages in organisations' safety cultures

Figure 15

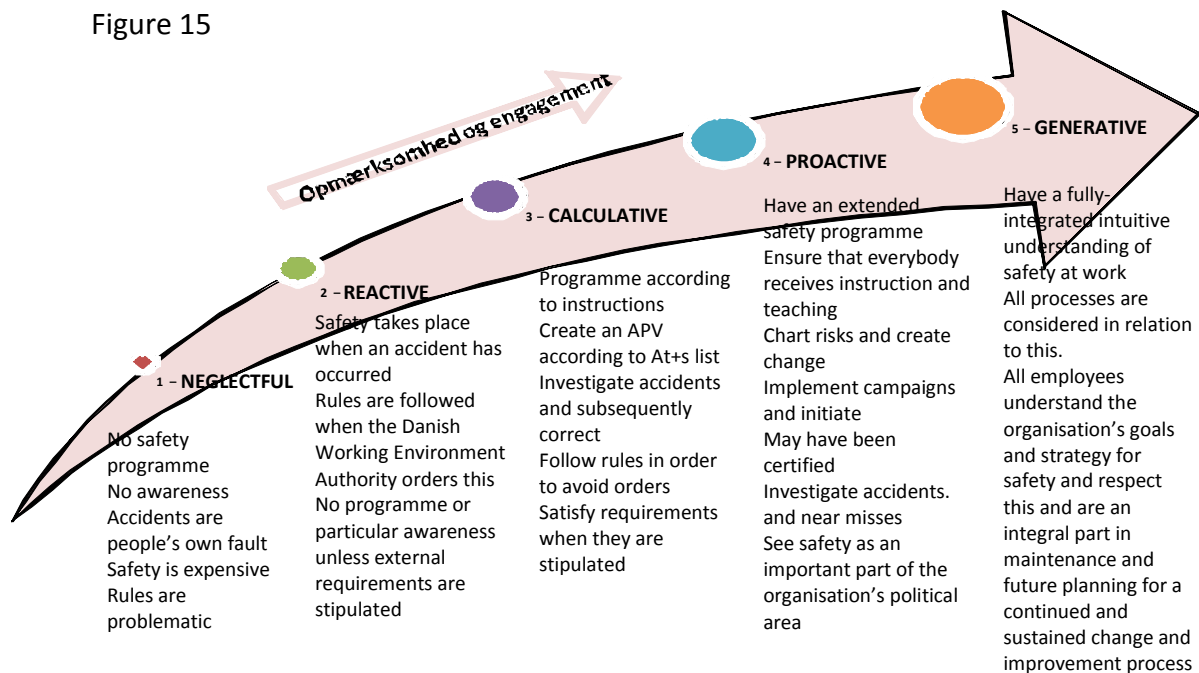


Figure 15 shows a moderated version of Shell's five stages of organisation safety cultures

This classification is based on Westrum's (1993) five stage development scale for safety culture in which:

1. Pathological or neglectful management has absolutely no interest in safety, but is more aware of how to avoid discovery by inspections conducted by the authorities, for example, whilst.
2. Reactive management primarily focuses on safety when an accident has occurred. Therefore the accident is investigated, but otherwise nothing more is done on the basis of an attitude that when nothing has happened, things are probably as they should be and the employees must otherwise be attentive.
3. Calculative management does what now must be done. It bases its safety on a system of auditing, procedures, statistics, etc. If all of this is in place and has been assessed by external professionals, then everything must be in order.
4. Proactive management focuses on strategies and processes. It allocates resources for safety and involves all tiers of management and the employees with the intention of creating ownership of safety throughout the entire organisation.

5. Generative management is chronic in the indications relating to risk. New ideas are welcome and safety is considered to be a profit area with development potential.

Even though great developments have been made in the knowledge about how accidents can be prevented, the statistics of reported accidents do show that there is still a long way to go before organisation will have succeeded in controlling risks and the causes of accidents (Cardieux et al 2006).

One conclusion is that the current approach to safety initiatives within organisations is not adequate. The way that safety is measured and assessed in the organisations is also questioned. Therefore a large number of researchers indicate that measuring consequences, i.e. the number of accidents, is not an adequate measure of the level of safety. Even if no accidents are reported for a period of time, it cannot be concluded that the safety conditions are better than in some other period when accidents were reported. It is actually the case that when an organisation is able to reduce the probability of accidents occurring, it will no longer be possible to deduce the level of risk from the number of accidents, which will instead be an expression of coincidences.

Also, when an organisation provides incentives to accident reduction and measures this, there will be a risk that the employees will instead be motivated not to report the accidents that occur rather than have the risk eliminated (Cardieux et al 2006).

Alternatively, measuring a number of different factors directed towards a proactive prevention and safety culture should be considered. In their research, Cardieux et al (2006) propose the following nine areas:

1. The organisational system – whether the safety system, its purpose, programme and results are considered to be just as important in the organisation as other factors of the organisation.
2. Management commitment – the behaviour of the management within the organisation including proposals for improvements, allocation of resources, investment in and measurement of activities, respect for own rules.
3. Employee responsibility – the behaviour of the employees towards procedures, including maintaining equipment, cleaning, training, involvement and compliance with agreements.
4. Standards and behaviour – the standards of the employees that support or impede safe behaviour.
5. Continuing improvement – implementation of the activities decided upon with the intention to improve and continually develop and evaluate this.
6. Safety-related activities – the specific activities in the area of safety that have been established and implemented and continually updated.
7. Organisational structure – the formal structure of safety issues, including the function of the safety organisation and the integration of safety into the management hierarchy.
8. Communication – information and dissemination of all safety-related matters and the dialogue between employees and management that is required by continual awareness of safety.
9. The work place's compliance with safety procedures/ rules – the extent to which the organisation actually succeeds in ensuring that each work place and work task

can be performed in accordance with both internal and external requirements and rules.

2.3.5 Managerial orchestration

Creating safety and preventing accidents is a difficult undertaking, principally because it is never known whether what has been done is sufficient and whether new situations have arisen for which no allowance was made.

This is also the reason why the task is associated with both a managerial prioritisation and an employee involvement and engagement and it must also contain the eyes, ears and mental activities that through dialogue with the management can create awareness and communication of risks, dangerous situations and any need for adjustments, adaptation and continual development.

We speak of the management that is needed as being multi-faceted and of there being a type of orchestration of initiatives, methods, processes, etc.

1. The promotion of safety rather than accident prevention

The first thing to be established is that it is the promotion of safety rather than accident prevention that can lead to a high level of safety. The knowledge that is acquired within an organisation from its own accidents and near misses can primarily be used to monitor how things are going and if relevant identify which safety barriers are faulty and where there is need to invest further in training and situational awareness. The risks that may be encountered are those that are shown by major statistical analyses for the relevant types of jobs and those that can emerge from a job analysis and the observations from daily work situations that can be reported by employees. On the basis of this plans for safety barriers and message maps can be devised, which can be subsequently used for training and monitoring.

2. Strategic, tactical and operational management

The second argument for safety to be included in all tiers of management integrated into all other activities within the organisation. When discussing strategies, plans, activities and duties, the issue of safety must be included in a natural and integrated manner. The decisions that are reached at the strategic and tactical levels are generally of vital importance to the matters that the work tasks at employee level become. In addition, the employees will generally perform the work that they believe is expected of them by the management, usually quickly.

If the management wishes for something else, it must either ensure that it is credible and that the employees also understand that what is performed quickly is also safe.

3. Transactional - transformational

The third thing to be identified is the importance of involving the employees in taking responsibility for safety and that they are both motivated and inspired to contribute in a continual development of this. Here the management style is also decisive. If it is a purely top-down control in a transactional style, or if it is employee involving via a transformational style.

4. Objectives and feedback

In establishing goals at the strategic level and transforming them at both a tactical and an operational level into a collaboration with the employees, the management is able to create a living culture and development in the area of safety. However, this must also be maintained through monitoring, measurement and feedback so that it is obvious that this is a priority area for the management as they monitor and react if the level is not maintained as a minimum or is instead continually improved and developed.

5. Learning process, political process, symbolic process

It is recommended that the change management concept is employed as a strategic choice for use in these management activities. This involves focusing both on creating a learning process, a political-organisational process and a symbolic process that can all interact and contribute to creating the change to the safety culture desired by the management.

6. When safety degenerates

It is not uncommon for the management to promote a dangerous practice, even though it is not in violation of the formal safety policy. (Nichols and Armstrong 1973).

This is applicable, for example, if they exert pressure on the timely completion of tasks or if they give the order that tasks are to be completed despite the fact that the technical equipment is not in order or a training course has not been completed.

In order to counter this and ensure the overall responsibility for safety, it is necessary to create a high level of safety awareness amongst those who are in a prominent position to consider safety in the overall agenda. The managerial attitudes such as low fatalism, high safety prioritisation and high risk awareness have shown themselves to be of particular significance (Rundmo et al 2003)

Rasmussen (1997) also puts forward the argument that safety will degenerate when nothing has happened for a while. There is therefore a gradual relaxation of rules and awareness, influenced by the desire to be more efficient and have less problems - when nothing has happened for some time and we feel that we have control over it. Rasmussen calls this “The drift to danger”, which is an effect that has over time been demonstrated in a large number of serious accidents. Figure 16 illustrates this “drift to danger” as an important argument for safety being something that must at all times be upheld and maintained. The work is never complete.

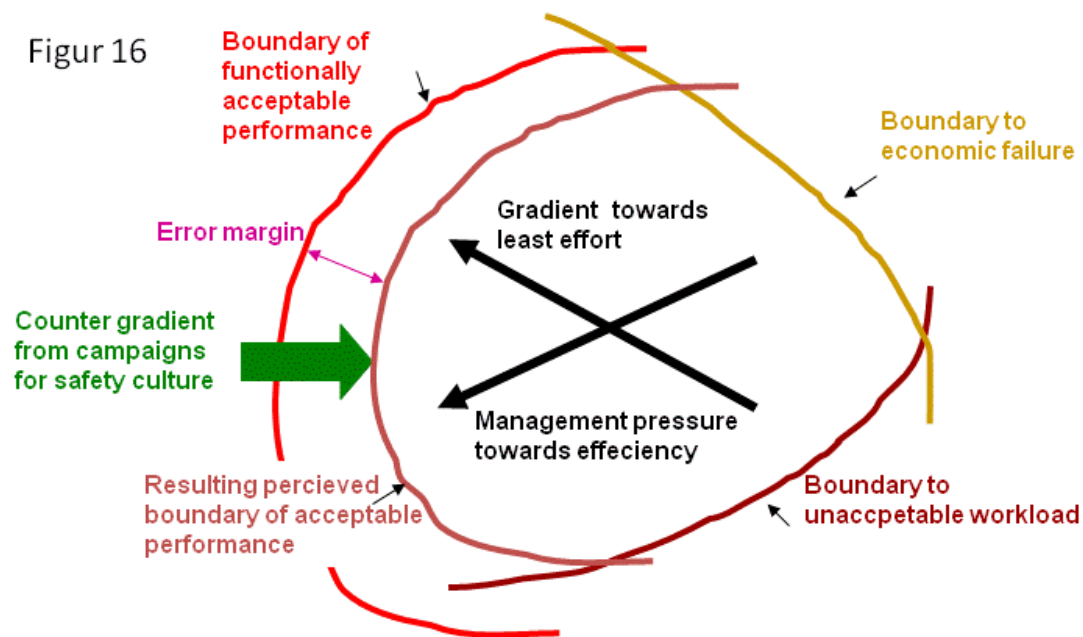


Figure 16 illustrates “The drift to danger” first formulated by Rasmussen in 1997.

2.4 The small organisation and safety arrangements

The research that has been conducted into the area of safety has largely been based on organisations with risks that could have disastrous consequences, the so-called “high-risk organisations”. At the same time this research is closely related to large organisations and not least to international groups.

In Denmark in excess of 178,000 companies with employees and in excess of 121,000 sole trading companies are registered. Among the companies with employees 85% have less than 20 employees, 10% between 20 and 50 employees, 3% between 50 and 100 employees and only 2% have more than 100 employees (StatBank Denmark, trade and industry statistics for 2007).

That is to say that safety activities in the more general areas in terms of risk should be targeted toward the small organisations. However, the question is whether the results that have been obtained from large organisations can be used in the small organisations.

A limited number of research projects have been conducted that chart the health and safety problems of small organisations, including their organisational forms and management structures. (Hasle et al 2004) have conducted an extensive literature study of the work environment activities in small and medium-size organisations, which summarise the primary research results. The following, among other things, is demonstrated:

- That the safety within small organisations is largely determined by the culture and understanding that the employer and the owner of the organisation has in relation to the aspect of safety. It is the owner who is the focal point for the tasks and duties of the organisation and who is responsible for the way in which safety is prioritised and implemented into daily work. At the same time, the owner has many different duties that must be attended to in his or her daily work and he or she will usually perceive systematic work environment initiatives as one of the more peripheral tasks (Hasle et al 2004).

-That systematic work environment initiatives in small organisations are usually limited, and that the same applies to all other types of systematic planning and management. The employer or the owner has a tendency to surrender responsibility for safety to the employees. The employer usually views safety as an individual problem and only the necessary safety equipment is provided. (Axelsson 2002, Hasle et al 2004).

-That it is important to recognise that employers and employees in small organisations are witness to very few accidents and therefore have limited opportunities of gaining their own knowledge of the hazards that can lead to accidents. For this reason, among others, the understanding for safety being an important topic is similarly limited. (Hasle et al 2004).

-That over the last 5-10 years a number of different methods and tools have been developed, which have been trialled in small organisation, but the general experience is that it is difficult to disseminate and create interest in the results within small organisations. Small organisations need to realise that these results provide them with something they can use in their daily work. Something that can make the average day a bit easier and which is immediately understandable as regards why and how these should use these results. It is also known that the employers of small organisation are motivated by personal contact and when they are given the opportunity to exchange experiences with colleagues. (Hasle et al 2004).

- That small organisations in the traditionally regulated market do not have the resources at their disposal that are required by the paperwork for a safety management system in a rule-based system. Employers of small organisations need to rely on their employees' abilities and the mutual more informal communication to a far greater extent.

2.4.1 Challenges within the small organisation

The formal framework within the small organisation is generally limited. It is still the employer who sets the agenda, i.e. decides which tasks are to be performed and under what circumstances.

The employer often has a close, almost familial relationship with the employees, but in quite a few industries the employer needs the employees to be able to act independently.

The informal framework, including planning and organisation, mean (among other things) that the communication paths are short. Immediate action is only taken when a decision is taken (Hasle and Limborg 2004). This means that when a demand for systematic management activities is made, for example systematic access to work environment management, the small organisations do not participate. This is too time-consuming and expensive and does not fit in with their way of working. (Antonsson and Smidt 2003).

This means that the requirement for systematic strategic planning and organisation, which is prescribed in the methods to achieve the high level of safety, does not generally have an actual basis in the small organisation. On the other hand many of the elements that are included in safety management and safety culture will also be necessary in the small organisation.

The challenge therefore lies in how to use the best from the large organisations adapted to a form that fits in with the everyday situation of the small organisation. Some of the facts that makes this difficult in the small organisations include the five following points:

- The fact that the accident frequency is high, but the risk awareness is low

- The fact that culture and organisation are extremely different for different industries, professions and individual employers.
- The fact that management resources are small, so must needs to be delegated to each employee.
- The fact that the gains from a high level of safety are difficult to monitor.
- The fact that resources for safety activities such as finances, time and knowledge are limited.

High accident frequency, major underreporting – low awareness

It has been shown in many other countries besides Denmark that the accident frequency is higher for small organisations than for large organisations (Vickers et al 2003, Walters and Lamm 2003, Eakin et al 1998). This has been partly shown in the EU by the countries that have adequate coverage of registered occupational accidents. Among these, Eurostat data for 1996 showed that organisations with less than 10 employees had an accidents frequency of 6.8 and organisations with between 10 and 49 employees had a frequency of 6.3, whilst organisations with in excess of 250 employees had a frequency of 2.7 (Eurostat 1996).

The Danish recording of occupational accidents has an underreporting of around 50%, which is probably particularly due to the fact that the smaller organisation do not report their accidents. This is either because they do not know that these must be reported, do not have the energy to report, or are disinclined to report.

On the other hand the individual small organisations experience accidents relatively seldom among their own employees and should an accident occur, it is often an accidental event that the employer feels he or she has no blame for. The vast majority of accidents are so-called “commonplace accidents” such as falls, collisions with objects or dislocation of muscles by heavy lifting.

What is commonplace about these is that the events are simple and easy to explain, afterwards that is, but these accidents also have a strong element of human behaviour and actions at the same time the conditions that create the accidents are perceived as being everyday occurrences and not as something especially dangerous. This also involves a lack of competence in the small organisation in investigating and analysing accidents (Walters 2001). All in all this means that the awareness of dangers and their possible consequences is generally low.

Culture and organisation for different industries, professions and employers

Small organisations are not a homogeneous group that can be referred to. They represent an extremely inhomogeneous collection of organisations and people with individuals who may have become employers by accident. The large industry groups that are dominated by small organisation include agriculture, construction, commerce, knowledge services, which together constitute scarcely 50 % of all small organisations. However, only these four industries are characterised by very different cultures and ways of organising themselves.

It can also be seen from the information provided by Statistics Denmark that a fairly large number of organisations close down every year and just as many new ones usually appear. Establishing yourself as a company in Denmark is very straightforward and you can start by acquiring a VAT number and then start work. The managerial skills in small

organisations in particular are associated with whether they are familiar with the tasks and therefore perform them by themselves and with the help of others.

The organisations that survive are naturally those that perform well and which can be able to continue acquiring the tasks. However, this is also what is the most important. To be doing well and the relationship with the employees being important is shown in the majority of studies of small organisations, which also describes the familiar and often patriarchal relationship that exists between employees and employer (Vickers et al 2003, Hasle et al 2004).

However, if the culture is that you have to be able to manage by yourself and each must be able to take responsibility for him or herself and own work, a large proportion of the employers will also perceive this as applying to issues of a safety-related nature (Hasle et al 2009).

This is confirmed by the studies into the small organisations where the distinguishing mark is that accidents are caused by the employees themselves, especially if the employer has ensured that resources are made available (Vickers et al 2003, Eakin et al 1998). If accidents occur they are a surprise and are perceived as isolated events and they are therefore often interpreted as accidental accidents that are either due to personal “stupidity” or an almost inevitable destiny (Hasle and Limborg 2004, Hasle et al 2009)

The management resources are small and the delegation of the work is a necessity

The limitation of managerial resources in small organisation is generally pointed out in the literature that deals with small organisations. There may be no use for the large formal systems when the issues can just as well be discussed in the everyday situation. Therefore also the informal framework and an often ad hoc characterised arrangement of the work. (Hasle et al 2009, Walters and Lamm 2003, Eakin et al 1998)

In addition, the work tasks in many small organisations are characterised by their needing to be performed outside of the organisation’s premises or away from where the employer is based. This applies to, among others, the construction sector, within commerce, within agriculture, in the cleaning industry and within the transport industry, etc.

The two industries that are included in the DanWorm project are the carpentry profession and the caretaking profession. For both of these two professional groups independence in the dealing with tasks is pronounced since the employer is not on site and therefore cannot monitor or in some other way verify whether the work has been performed safely.

In particular the tasks of carpenters in small organisations bear the mark of work places, work tasks and work conditions changing on a daily basis and over the course of the day. This requires each carpenter to be able to take care of his or her own safety in very different situations, but of course the employer must also ensure that the carpenter has a basis on which to do so.

As regards caretakers, in many cases their employers are estate offices at other addresses and on a daily basis they are left alone to attend to various tasks in a specific property. These work tasks are to a certain extent fixed, but some are completely dependent on problems with residents, rain and poor weather, structural maintenance and waste management, etc. He or she is also often alone whilst working and must be able to operate in the situations that arise. Here his or her options are also conditional on the employer having created the basis to allow him or her to act safely, but whether or not he or she does so in the situation is his or her choice.

The gains from a high level of safety are difficult to monitor.

In many contexts it is postulated that safety can pay and that accidents are costly. If a serious accident affects a small organisation, this can also mean that the organisation will not be able to bear the cost and not at all if it affects the employer.

However, as has been stated such accidents are rarely experienced in organisations and at the same time the accident is seen as something that is very random as regards where and how the accident strikes. It is for this reason, among others, that it is difficult for the small employer to relate to the argument that safety pays.

He or she believes that time and money should be spent on obtaining equipment, drawing up instructions and work place specifications, etc. without the employees wanting to use these or put a price on their efforts. That is to say that he or she sees safety as something that is costly. (Brooks 2008).

The challenge lies in making the employer see the costs of safety in relation to the risk rather than the actual accidents so that he or she is given an opportunity to assess the value of safety rather than spending money on something the effect of which he or she will not be able to see.

Financial, time and knowledge of dangers and safety resources are generally limited

It is also stated that the resources of the employer and business owner in a small organisation are limited in terms of finances and time and not least in terms of activities that are considered to be peripheral in relation to what the money is earned from (Brooks 2008, Walters and Lamm 2003)

It is also generally the case that the employer and owner of a small organisation primarily have a professional knowledge on what the organisation is based on and not special knowledge of safety and work environments. Nor is it the topics about which he initially begins to acquire knowledge: Economics and accounting, authority regulations, sales and customer contact come first.

Nor will knowledge of safety immediately be at the top of the list when staff are being appointed. It is more about being able to make them perform the tasks for which there are customers. In small organisations there may be opposition to investing, in particular in equipment and tools (Vickers et al 2003).

In small organisations there is not generally time to familiarise oneself with new technical areas, e.g. work environments and safety that are not immediately product-relevant (Walters and Lamm 2003) The employer therefore needs to be given a plan and method, which have been devised by others with the requisite knowledge, but which satisfy his or her criteria of having to be inexpensive, easy to use and maintain and adapted to his or her tasks and industrial requirements (Vassie and Cox 1998).

On the other hand, customers from, for example, larger organisations may make demands on safety competences, which can have a positive effect on prioritisation in small organisations. This is therefore also one of the methods that is indicated as being the way forward in strengthening the awareness, prioritisation and competences of small organisations. (Vickers et al 2003)

2.4.2 Safety arrangements of the small organisation

In relation to their operations, smaller organisations often have a great potential to act and a good ability to adapt to changes to everyday conditions (Hasle and Limborg 2004). This is also an advantage that means that they are able to demonstrate very good flexibility in the performance of their tasks, which justifies them in the labour market.

The owner/manager is often also the founder and “father” of both the product and to the development of the organisation. It is therefore his or her perception of product quality, precision, pace, order and standards that is the basis for the safety culture within the organisation (Hasle and Limborg 2004)

It is therefore still the case that safety begins with the manager and his or her decision that safety is to be an important parameter within the organisation irrespective of whether the organisation is large or small.

Kogi (2006) has gathered experiences from a number of Asian countries of how participant-based safety initiatives in small organisations have been successful and which immediately appear to have a general nature. Other initiatives include the German “Employer Model” (Eichendorf 2001) and the Danish project concerning “controlling order and safety” (styr på orden og sikkerhed) (Hasle and Limborg 2004)) support Kogi’s results.

Kogi states two primary criteria:

- 3) That improvements are best achieved if local knowledge of best practices is used and assistance is given in disseminating this knowledge via dialogue between local groups. In connection with this, the importance is highlighted of the objective for the small organisation being the use of good local practices, to be shown self-help actions at a low level of cost and to provide an experienced facilitator with support for a continuous process.
- 4) That a starting point has been taken in the positive features of small organisations that include the informal style of management. Also the use of local people, as we communicate best with people that we already know.

Kogi illustrates the step-by-step action programme for locally-established groups of employers from small organisations, as shown in Figure 17

The first problem that is encountered in increasing safety in small organisations is therefore in creating understanding and insight in the employer in that he or she should give safety a high priority. As his or her own experience is that accidents do not happen and everything is fine. However, if and when the manager decides that safety is to be prioritised, he or she will need readily available information about the risks that need to be focused on and what needs to be done in this regard. He or she generally does not have the energy, knowledge or experience to look for knowledge in a multitude of different places nor the resources or people to manage a safety function within the framework of the organisation.

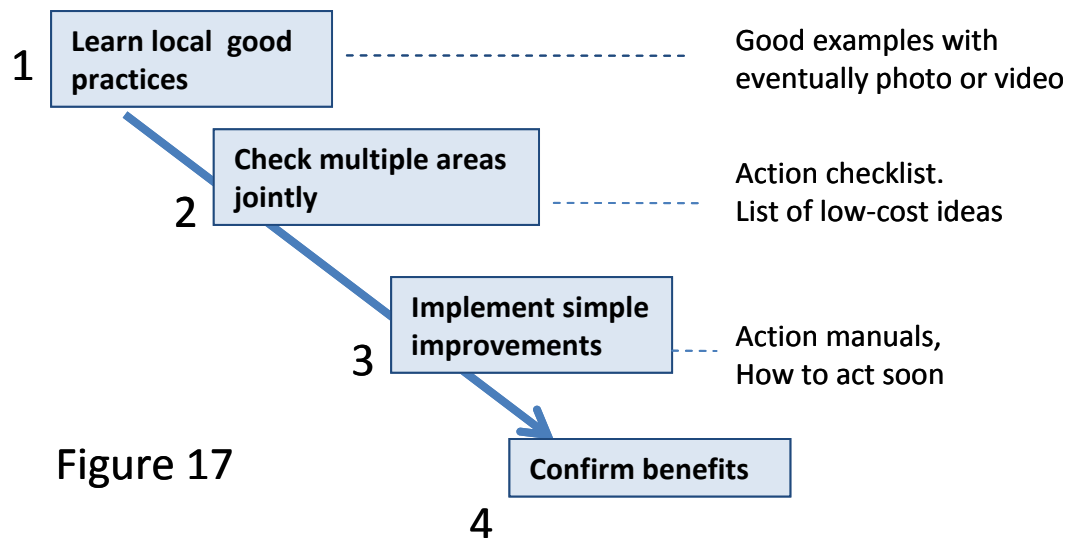


Figure 17

Figure 17 shows Kogi's model for a step-by-step action programme targeted at small organisations' participant-oriented introduction of safety programmes (Kogi 2006)

At the same time he or she will need his or her employees to be able to act independently to a large degree, i.e. that through their basic training will have gained an insight into working safety and that they will know how to organise their work. Studies indicate that many employers in small organisations find it difficult to convince their employees that safety is important and that they must observe risks and act appropriately with regards to safety (Vickers et al 2003).

The employer finds it too difficult to provide guidance as he or she cannot be present all the time where the employees are working. This applies in particular to the industries in which the work tasks are performed away from a home address, e.g. construction, transport, agriculture, etc.

For both parties it may be helpful to acquire a tool that would enable them to see risks and observe safety barriers as well as being aware of the necessary measures and provisions.

This must be readily available as there are not many resources available in addition to what is needed to complete the work tasks. The goal must be to provide the employees with the skills that mean that the way in which they think that a task needs to be performed is fully integrated with performing the task in a safe manner.

This requires a general understanding for tasks and jobs, especially in work that is performed outside of a "home organisation", i.e. at different geographic locations to where the employer has his or her office. There will be special requirements here when the employees have to relate to new surroundings and new work conditions on a daily basis.

It would not be physically possible for an employer to be present at all such work places and assess their safety. In these situations he or she must rely on the employee being able to do this at the same time as attending to a customer commitment.

Independence and self-management in relation to safety at work therefore becomes especially necessary for employees in many small organisations. This places some particularly high demands on both employer and employee in relating to the safety requirements. The basis from the home organisation must be in order with regards to equipment, resources, instruction, time and work scheduling and the employee must be

made aware of how he or she should behave, what observations need to be made and how he or she must conduct him or herself generally.

However, there are many indications that there is not an implementation problem in small organisations, but more of an awareness problem. Why – when there is no longer anything happening and how – except that it is too heavy in terms of costs and resources.

The major problem of making safety an important topic in small organisations is a task that must and will be broadly resolved by means of authority arrangement, initiatives of the parties and training systems, etc.

2.5 Summary

This chapter contains the theoretical basis for the DanWorm project and describes the understanding of accidents and their prevention on which the DanWorm project is based.

2.5.1 An understanding of the accident and its causes

The concept of the “occupational accident” is defined as:

” The occurrence of a sudden and unexpected event or series of events in connection with work that results in some injurious, cause injury to people, damage to material, processes, etc.”

The phenomena of the “accident” can most easily be analysed with the benefit of hindsight, i.e. when the accident has occurred. This report illustrates how such an analysis can be conducted with the aim of identifying not only the immediate causes, but also the underlying and more fundamental causes of the accident.

The review that is given in Chapter 2 shows, among other things, that accidents have many causes and it is the simultaneity of the causes that to a greater extent causes the accident rather than the presence of individual causes. However, given the fact that individual causes do not lead to an accident, this makes it difficult to single out the actual “culprits”. At the same time this means that it is difficult to perceive causes that in one situation do not have any significance but in another situation will be of significance to the occurrence of the accident.

It may be easy for this reason to direct the searchlight on the actions and choices of individuals when explaining the accident and identifying “the cause”. This is why there has been great focus on human errors and mistakes. A distinction is made between conscious and unconscious mistakes and between faults in performance, faults in memory, incorrect choices of method and between misunderstandings and inadequate knowledge presented by, among others, Rasmussen (1987) and Reason (1977).

This understanding of the different ways in which people make mistakes or act incorrectly is placed within a framework of explanations and conditions determined by the situation and context in which they find themselves. Reason (1997) states in his model how organisation, decisions and work conditions are of significance to which risks are present and the safety barriers that are necessary to prevent accidents occurring.

This brings us over to looking at the understanding and perception of risks as important elements in people’s ability to perceive risks, know which dangers these contain and the consequences of a potential accident. Basically this review leads us to the conclusion that people are not particularly good at or have the opportunity to assess risks. Some risks are

considered to be high and other low and this suggests that so many other factors in our lives and surroundings have significance to what we understand and perceive. This sometimes has the effect that we perceive a situation incorrectly or quite simply make a mistake, which can lead to an accident.

We must instead look at the multitude of factors that are of significance to both the presence of risk and the causes of accidents occurring. An analysis of the different view of a number of researchers of this phenomena results in a taxonomy for the causes of accidents, in which the hierarchy of immediate causes, underlying causes and control-related causes is described and is placed in relation to the decisions, values and actions of the people involved on the one hand and the possible control mechanisms and technical measures on the other. (Jørgensen 2002).

This also points to the significance of all of the decision-making layers within an organisation and the organisational conditions for the way in which the safety arrangements operate and accidents are prevented.

That is important to have an understanding of the paradox that an accident and its causes are not understood until after the accident has occurred, whilst it needs to be prevented before it occurs. Quite a lot of accidents preventing measures within organisations involve investigating the accidents that occur in order to initiate action against the specific cases demonstrated by an analysis. However, Krause (1995) shows that this type only has a limited effect. He instead suggests that a much better preventative initiative is achieved when the management decides to obtain a higher degree of safety and a more target effect of the safety initiatives. It would be even better if the management is able to create a culture within the organisation in which the employees contribute to continual safety-related improvements.

The knowledge of the risks and causes of accidents that is needed in such a process needs to be obtained from investigations and analyses of a large number of accidents, but in such a way as to obtain the generic fundamental causes of the accidents and the generic measures, i.e. safety barriers, which can prevent accidents. The use of generic knowledge is vital being able to achieve the desired results.

The risks that are usually focused on are those that could result in very serious consequences if they were allowed to lead to an accident. 'Spectacular risks' in particular, where a large number of people are exposed to the risk simultaneously, receive a lot of attention, obviously for very good reasons. However, the fact of the matter is also that the so-called 'commonplace' and more common types of accidents have a very high occurrence and can have serious consequences to individuals. Many more people die as a result of such common risks than as a result of what are often termed 'high-risk' areas, which are more of a challenge in relation to doing something with these common risks than relaxing the protection against the risks that are in focus.

2.5.2 Instruments for proactive prevention

Three types of instruments have been implemented to be used for proactive prevention.

The first is assurance of the safety barriers, both technical and organisational, that will prevent accidents from occurring, the second is the situational awareness that must be instilled in people to enable them to take the correct action and the third is methods of gathering and disseminating knowledge of the relevant dangers, risks and their safety barriers by means of so-called 'message maps'.

For the safety barriers, a distinction can be made between the active and passive safety barriers, where the active barriers require active action from systems or people in order to function, whilst the passive barriers function by virtue of their presence alone. The safety barriers are also divided into preventative safety barriers, which protect against accidents occurring, protective safety barriers, which ensure that injuries do not occur even if an incident does occur and limiting safety barriers, which contribute to minimising damage.

There are several ways to describe the different types of safety barriers. The description given in the ARAMIS report by Hale & Guldemund (2003) is very easy to understand. Here the safety barriers are divided into technical safety barriers and behaviour-affecting safety barriers and combinations of the two. This overview clearly indicates how important it is that the technical safety barriers are both provided but also installed, inspected and maintained for optimal operation. The behaviour-affecting safety barriers are connected to procedures, plans, rules, resources, competences, adaptation, obligations, coordination and communication. All in all, a large number of conditions that must be established by the organisation, including the way in which the work is organised.

Situational awareness has been defined by Endsley (2000) as:

"The perception of elements in the surroundings within a space of time and place, the understanding of their significance and prediction of their status in relation to what will occur in the near future."

Endsley (2000) lists a number of factors that are of significance to what a person has his or her attention drawn to. He states that goals determine perceptions and understandings and the direction of attention that Endsley therefore suggests, that if we do not understand what an individual's objectives are in a specific situation, the information in the environment will therefore have no meaning. In addition to this, prejudice and expectation will influence situational awareness.

In reality, people need to act on the basis of more than that which contains the immediate information in the situation. They need to be able to combine information and imagine events that exceed what lies behind their experiences. They need to be proactive and not just reactive. They need to act on the basis of objective and be able to act with a certain degree of automatic and knowledge-based behaviour.

A lot is therefore based on competences to be able to observe, know the significance of what is being observed and act correctly on the basis of this. Bellamy's (2008) competence steps can provide an overview of where an individual is or believes that he or she is. There is good reason, for example, to expect that this very unconscious incompetence is contributory to many accidents, not least among young people and new employees.

A tool used to create an overview of safety barriers, risks and appropriate actions is the development of 'message maps'. These have been developed in order to create an overview of which users have a need for what information. Their purpose is to make an individual able to take decisions and action that is directed at his or her own needs. Flin et al (2006) set up 'message maps' as a means of creating situational awareness to be used in decision-making and communication and cooperation. It is also possible in this way to establish how managers can support this process.

'Message maps' can be used in proactive accident prevention by specifying which consideration should be present in the person's head. That is to say a method to ensure that the situational awareness is correct and that appropriate action is taken by specifying

the observations, which need to be made and the safety barriers that need to be in place in order for everything to progress as it should, and the action that is required is the conditions are not in order.

2.5.3 Managerial and control concepts

Over time there have been many examples of organisations that have achieved a high degree of safety. Some of the characteristics possessed by these organisations are that the management has taken the issue of safety seriously and given this high priority in the organisation's strategy and organisation.

It is also stated that safety should be integrated into the strategic, tactical and operational management of the organisation and that the line management is given responsibility. However, again it is quite inconsequential how this takes place. Flin and Yule (2004), among others, point to the difference between operating transactional management, which is characterised by a purely top-down style, and transformational management, which to a far greater extent is a participant-oriented and employee-motivating style.

The top management, middle managers and general management each have their own functions and significance for how safety is operated within an organisation. The general management must be able to understand the art of supervising and communicating the priority of safety. For example, it has been shown that the more that safety is discussed and integrated into conversations about the performance of the general management, the greater will be awareness amongst the employees and also safety.

Generally middle managers largely adopt the decision that are outlines in strategy and action plans and they are therefore of vital importance as to whether the general manager and the employees are given the opportunities, facilities and resources that are needed in order to perform their work tasks in a safe manner. However, everything begins and ends with the prioritisation and commitment that the strategic management establishes and exhibits in a continual dialogue and communication within the organisation.

One of the managerial methods that has shown results in particular with regards to safety is the establishment of an objective, implementing it, monitoring and giving feedback on how it progressed in order to then set new objectives, etc. However, here it is also the case that involving the employees is important, i.e. that the initiatives are implemented in a transformational manner. Furthermore, it is vitally important that the plans are credible, realistic and based on mutual trust between management and employees.

It is essentially a question of a management task for the majority of organisations that wish for an improved level of safety. The principles of change management can therefore, with advantage, also be used in the area of safety. Therefore initiatives must be implemented to create a learning process both for the managers and the employees, a political process that allocates responsibility and integrates safety both generally and in the day to day work and a symbolic process that contains stories, successes, visibility and clarification of the culture that is necessary in order to maintain a continuously high level of safety.

What is most important is therefore the creation of a good safety culture, which as has been shown, can only take place by employing a number of different initiatives, methods, strategies and processes. The literature gives a number of different messages about what safety culture is and how it can be created. Awareness and involvement on the part of the management are two of the key words. In Westrum's five-stage scale there is an excellent model for the categorisation of organisations' levels of safety. Here a distinction is made

between the neglectful manager, the reactive manager, the calculative manager, the proactive manager and the developing manager.

A number of methods have been developed to measure and categorise safety culture, but without a suitable method having thus far been identified. The fact of the matter is that the safety culture can vary in the people that an organisation consists of, the tasks that are performed, the conditions determined by the surroundings, the economic frameworks, etc. Furthermore, the level of safety has with this fallen over time according to Rasmussen if we are not continually aware of whether the limits for the level of safety moves. It is therefore important to have a long-term and constant focus on risk, even if accidents do not occur.

2.5.4 The small organisation

A characteristic of the management of the small organisation is that it is informal and largely determined by the manager's culture and understanding of the performance of the work and maintenance of safety. It is not uncommon for the employer in the small organisation to view safety as the responsibility of each employee when he or she only contributes to providing the equipment. In other situations the manager is not concerned with safety at all. It can be said that generally the majority of small organisations are at the low end of Westrum's five stage scale.

The low awareness of the causes of accidents and consequences in small organisations is due in part to despite a higher accident frequency, they experience only a few incidents within their own organisations. This makes it difficult to achieve a prioritisation of risk awareness, situational awareness, safety competences and knowledge of safety barriers in the small organisation.

At the same time small organisations are very different, partly due the tradition-bound cultures and standards of the industries and unions, partly due to an individual manager's own standards and values and finally due to the context in which the small organisation is to be active, e.g. independent of demands from large organisations or from local small customers, etc.

One important aspect is that it is immediately difficult for the manager of the small organisation to see what gains can be achieved in using a lot of resources on safety, apart from taking his or her time and money, which is already limited. On the other hand the literature shows that if the manager of the small organisation already understands what he or she can do and what he or she can gain from this, the decision path is short and the potential for action is great.

This therefore applies to developing methods and materials that can be targeted at the small organisation in a way that is easy to understand, easy to use, requires few resources and which can immediately be included in the usual work. An implementation of new methods must also involve local practices, illustrate the application of and gains from the methods principally within the industry or professional area of the small organisation and be very readily communicated from somebody that is already known by the small organisation.

New methods and processes can also be implemented advantageously via technical training so that the employees are actually aware of risks, safety barriers, observations and options, for example, through their training and thereby impart this knowledge to the small organisation.

Whereas the orchestration of safety in the large organisation can be placed on strategic management and a large administrative apparatus, in the small organisation it must be incorporated into a social structure. We will now conclude with Lund and Aarø's proposal for how to create an increased understanding of safety within a society, which is shown in Figure 18.

Figure 18

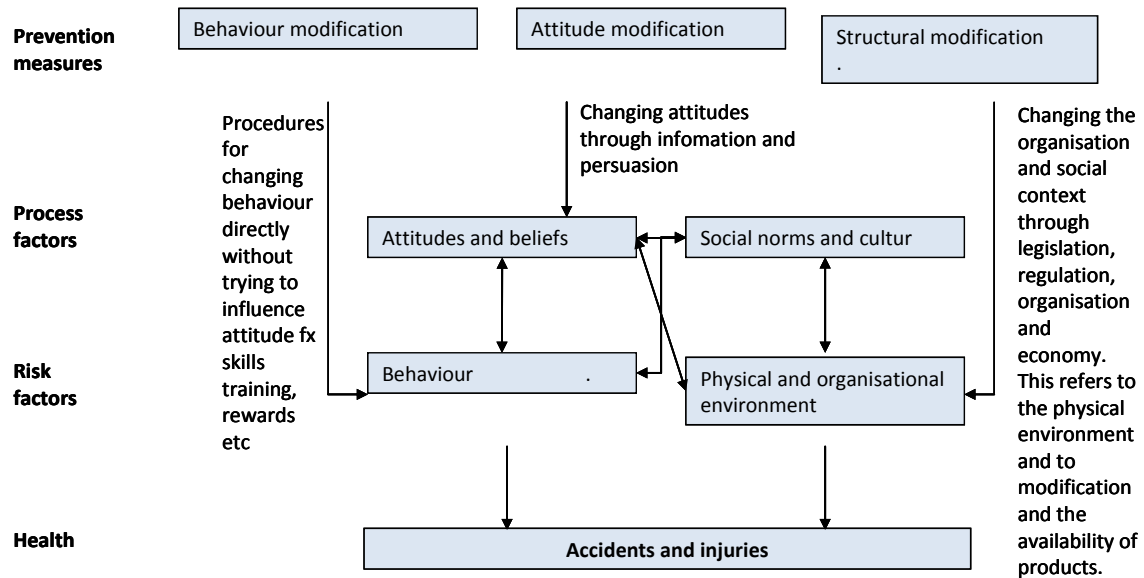


Figure 18 illustrates Lund and Aarø's concept for influencing social attitudes and standards in relation to accidents (Lund and Aarø 2004).

The thinking behind this model is that if we wish to achieve success in the area of safety, behaviour-modifying initiatives, attitude-creating initiatives and structural initiatives need to be implemented in a coordinated and targeted process. Each of these initiatives by themselves have very little effect. (Lund and Aarø 2004)

3. The Dutch WORM project

In 2003 a major Dutch project, WORM, was initiated by “the Ministry of Social Affairs and Employment”. WORM stands for “Workgroup on the Occupational Risk Model” and its purpose is to develop a basis for calculating the risk of occupational accidents in any task at work. The background to the project was obtained from the work on “I-RISK – A quantified integrated technical and management risk control and monitoring methodology”, which is the result of a European research project concluded in 2000 (European Commission 2000).

The I-Risk method was devised to be used in the high-risk area and is based on the assessment of risks when using hazardous chemicals in processing plants. The aim is to be able to prevent major accidents and limit the consequences should such an accident occur.

The WORM project has a similar aim for occupational accidents, namely to develop a method and an electronic program that could support a management in its decision-making in its efforts to prevent occupational accidents.

The WORM project is reported in two primary reports,

- ” The Occupational Risk Model – Final report of the Workgroup on ORM” (Ben Ale 2006),
- ” The Quantification of occupational risk – The development of a risk assessment model and software” (RIVM 2008).

In order to understand the whole project and its scope and results, reference needs to be made to these two reports and to the technical reports that are available by sending an e-mail to: cev@rivm.nl. These are the following:

1. Description of the project organisation
2. Overview of methodology, production steps and quality control
3. Occupational accidents in the Netherlands, Storybuilder & Storyfilter - The 36 Storybuilders
4. ORM logical model and Bowtiebuilder
5. Probability Influencing Entities and the PIE questions
6. Centre Event Mission Data
7. Exposure surveys
8. Bow tie models and quantification
9. Measures, effectiveness and costs
10. Activities, agents, jobs and bow tie links
11. Storybuilder software user manual
12. Bowtie builder software user manual
13. ORM software user manual

This section will only provide an overview of the structure and content of the WORM project and an insight into the product and results that emerged from the WORM project. Special emphasis has also been placed on the products that are used in the Danish project DANWORM.

3.1 Structure and content of the WORM project

3.1.1 Bowtiebuilder and 64 critical events

The basic model for the accident analyses in the WORM project is a “bowtie” model (bow tie model), which is a combined model of a fault tree analysis to the left and a cause-consequence analysis to the right, cf. Figure 19. The "bowtie" model is structured around a “centre event”, which we will in future call “the critical event” (den kritiske hændelse) in Danish.

The choice of "critical events" is vital to the analysis of accidents since the analysis of both causes and consequences takes its starting point from here. In fact different types of undesirable events can be perceived as both causes and consequences completely independently of the location of “the critical event”. However, the fact of the matter is that as soon as “the critical event” has been established, the description of causes and consequences will solely concern the specific critical event.

In principle a “bowtie” analysis exclusively consists of a description of the chains of events that lead to the critical event and the consequences that this critical event can have. By combining the analyses with a traditional fault tree analysis and cause-consequence analysis it is possible for each link in the chains of events to identify safety barriers that have been inadequate or have not functioned. The WORM project has used the understanding of the safety barrier concept that is described in Section 2.2.1 and Figure 10.

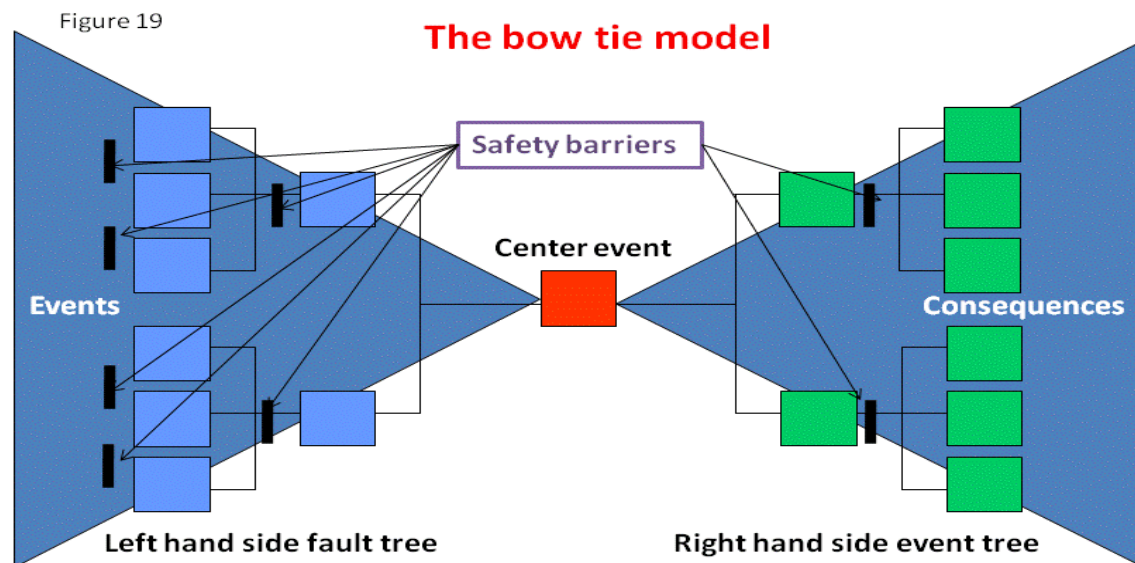


Figure 19 illustrates the "bowtie" model and the structure of the WORM project accident analysis

The prevention of accidents deals in principle with avoiding or minimising the consequences of critical events. In order to achieve this, the preventative actions must be directed towards ensuring that the safety barriers are in place and in order. That is to say that a management prioritisation has its starting point in the furthest right side of the model and its action space in the furthest left side.

What the bow tie model does is to create the image and relationship between these furthest points. The philosophy of the WORM project is as soon as this relationship has

been created it is possible to calculate the risk and determine which preventative initiatives are most appropriate to implement in order to reduce the risk.

Constructing an image of a bow tie for a specific critical event is a comprehensive process, which can be based on both a purely logical mindset and actual stories. In the WORM project a total of 36 bow ties have been developed, based on analyses of in excess of 9,000 accidents with either serious or fatal consequences. The analyses were conducted using a “storybuilder” method, which is described in Section 3.1.2.

The bow tie model therefore provides a relationship between the existence of specific causes and the probability of specific consequences occurring. In the WORM project calculations have been performed with three types of consequences:

1. Death,
2. Invalidity and
3. Serious but recoverable injuries

The data that is used covers those occupational accidents that have resulted in hospitalisations.

The right side of the bow tie analysis therefore covers the consequential process that the specific critical event has led to including the facts that can contribute to increasing or limiting the extent of the injury. The safety barriers that are found on the right side are the so-called ‘protective safety barriers’ that prevent or minimise the injury in a specific critical event.

The left side of the bow tie analysis covers all of the chains of events that have an influence on the occurrence of the critical event. The safety barriers that are found here are the preventative safety barriers that must be able to prevent the critical event from occurring.

In WORM an understanding has developed for the existence of primary safety barriers (PSB) and supporting safety barriers (SSB). For example, the method when loading a truck could cover SSB (method, rules, training, knowledge about weights, etc.), which will be of significance to the PSBs that must ensure that the truck is loaded so that it has good stability (position, weight limits, loading aids) in order to prevent losing control over the vehicle.

Information about whether they are the following can also be associated with all such safety barriers: (PUMM’s)

- Provided
- Used
- Maintained
- Measured

Figure 20

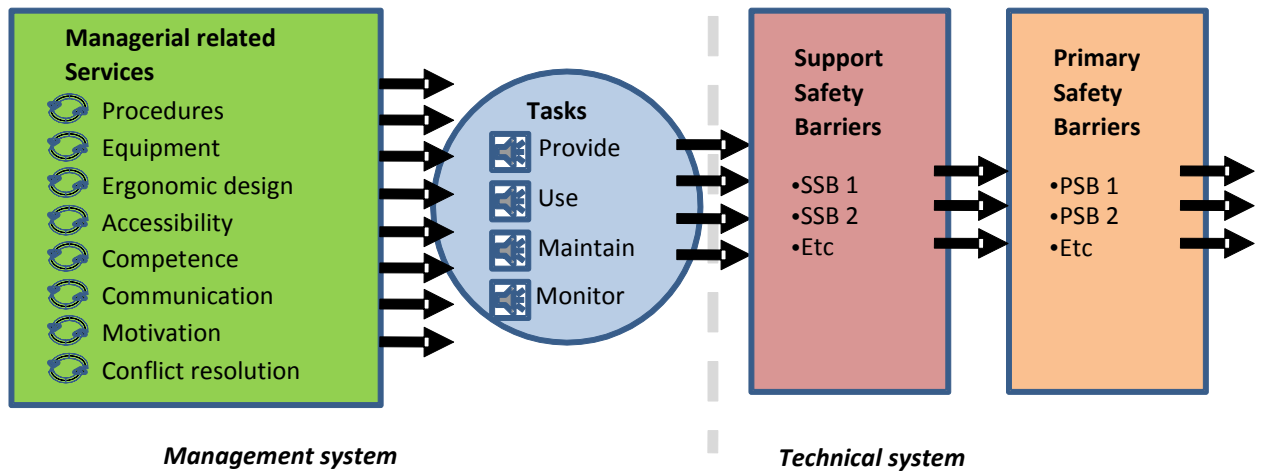


Figure 20 illustrates the performance system and barrier structure of the WORM project for safety barriers (RIVM 2008)

Which can again be investigated for, whether through the management and organisation of the organisation they are connected to:

- Procedures/rules
- Equipment/aids
- Design/furnishing
- Accessibility
- Competencies/training
- Communication/knowledge
- Motivation/engagement
- Conflict resolution (for processes/functions)

The relationships between PSBs, SSBs, PUMMs and the managerial performances are illustrated in Figure 20.

An example of how a “bowtie” can appear is shown in Figure 21 "fall from roof", where the safety barriers relate to the strength and durability of the roof, the person's ability to move on the roof and the presence of railings or other protection against falling. If the person does fall in any case, the height that he or she falls from and the hardness of what he or she fall on will have a significance to the size of the injury and the subsequent treatment that can be provided. Within each of the boxes there is information on PUMMs and other managerial services.

Figure 21

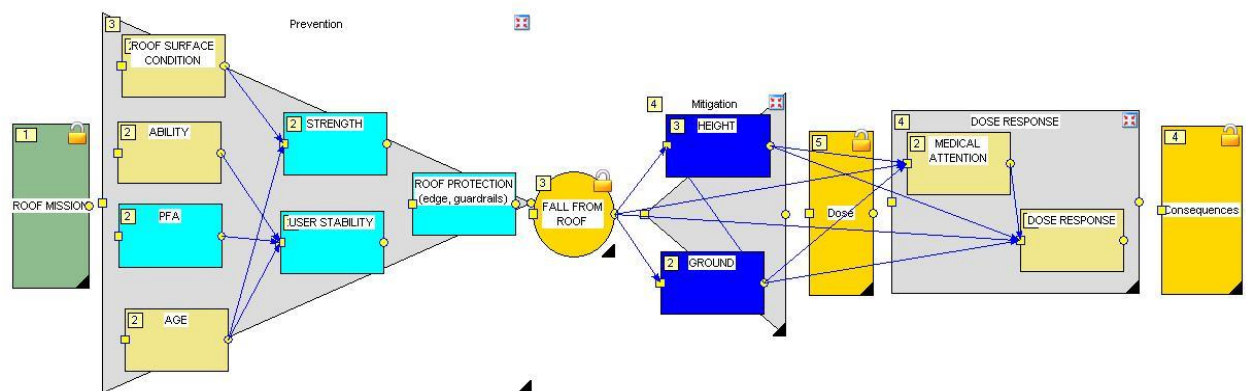


Figure 21 shows the structure for the bowtie model for “fall from roof”. The details in each box are obtained from a story builder, where the context, causes and consequences are described (RIVM 2008).

The “bowties” that are compiled in WORM represent 64 “critical events”, which can be understood as all of the events that can lead to a personal injury. Such a “critical event”, can also be understood or reformulated, such as “*Hazard sources*”. The 64 critical events or hazard sources are shown in diagram 11.

Diagram 11

No	Storybuilder- number and name	No	Bow tie Model – number and name
1	1.1.1 Falls from heights – ladder and step	1	1.1.1.1 Falls from heights – moveable ladder
		2	1.1.1.2 Falls from heights – permanent ladders
		3	1.1.1.3 Falls from heights – stepladders
		4	1.1.1.4 Falls from heights – rope ladders
2	1.1.2 Falls from heights –Scaffolding	5	1.1.2.1 Falls from heights – mobile scaffolding
		6	1.1.2.2 Falls from heights – fixed scaffolding
		7	1.1.2.3 Falls from heights – erection/dismantling of scaffolding
3	1.1.3 Falls from heights – Roof/ floor/platform	8	1.1.3.1 Falls from heights – roof
		9	1.1.3.2 Falls from heights – floor
		10	1.1.3.3 Falls from heights – fixed platforms
4	1.1.4 Falls from heights – hole in the floor/ground	11	1.1.4 Falls from heights – hole in the ground/earth
5	1.1.5.1 Falls from heights – mobile platform	12	1.1.5.1 Falls from heights – mobile platform
6	1.1.5.2 Falls from heights – stationary vehicle	13	1.1.5.2 Falls from heights – stationary vehicle
7	1.1.5.3 Falls from heights – other	14	1.1.5.3 Falls from heights – other
8	1.2 Fall at the same level	15	1.2 Fall at the same level
9	1.3 Fall on stairs and ramps	16	1.3 Fall on stairs and ramps
10	2 Hit by moving vehicle	17	2. Hit by moving vehicle
11	3.1 Contact with falling object - cranes	18	3.1 Contact with falling object –cranes and their loads
12	3.2 Contact with falling object –from other than cranes	19	3.2 Contact with falling object –mechanical lift
		20	3.3 Contact with falling object – from vehicle and their loads
		21	3.4 Contact with falling object –manual lift

No	Storybuilder- number and name	No	Bow tie Model – number and name
		22	3.5 Contact with falling object -other
13	4 Contact with flying object	23	4.1 Contact with flying object – from machines or hand tools
		24	4.2 Contact with flying object – from object under pressure
		25	4.3 Contact with flying object – that has blown with the wind
14	5 Being struck by rolling/sliding objects or persons	26	5 Being struck by rolling/sliding objects or persons
15	6 Contact with object that is used or carried	27	6.1 Contact with object that is in use or carried – hand tool used by other than the injured
		28	6.2 Contact with object that is used or carried – that is not a hand tool
16	7 Contact with hand tools used by the injured himself	29	7 Contact with hand tools used by the injured himself
17	8.1 Contact with moving parts of machines	30	8.1.1 Contact with moving parts of machines – under operation
		31	8.1.2 Contact with moving parts of machines – under maintenance
		32	8.1.3 Contact with moving parts of machines – under setup
		33	8.1.4 Contact with moving parts of machines – under cleaning
18	8.2 Contact with hanging/swinging objects	34	8.2 Contact with hanging/swinging objects
19	8.3 Mast/squeezed in between objects	35	8.3 Mast/squeezed in between objects
20	9 Thrust against object	36	9 Thrust against object
21	10 Buried under materials	37	10 Buried under materials
22	11 Inside or on moving vehicle that lose control	38	11 Inside or on moving vehicle that lose control
23	12 Contact with electricity	39	12.1 Contact with electricity – high voltage lines
		40	12.2 Contact with electricity – from hand tools and tools
		41	12.3 Contact with electricity – with electrical work
24	13 Contact with warm or cold surfaces or naked flames	42	13 Contact with warm or cold surfaces or naked flames
25	14.1 Lost control of contents from open containers	43	14.1 Lost control of contents from open containers
26	14.2 Contact with hazardous chemicals without losing control	44	14.2 Contact with hazardous chemicals without losing control
27	15 Lost control of containers that are normally closed	45	15.1 Lost control of containers that are normally closed – under the addition, removal of chemicals or opening of the container
		46	15.2 Lost control of containers that are normally closed – under transportation
		47	15.3 Lost control of containers that are normally closed – under closing of the container
		48	15.4 Lost control of containers that are normally closed – when working near them
28	17 Fire	49	17.1 Fire – warm work
		50	17.2 Fire – work near fire
		51	17.3 Fire – extinguishing fire
29	20.1 Aggressive people	52	20.1 Aggressive people
30	20.2 Aggressive animals	53	20.2 Aggressive animals
31	22.1 Hazardous atmosphere in closed room	54	22.1 Hazardous atmosphere in closed room
32	22.2 Hazardous atmosphere through respirator	55	22.2 Hazardous atmosphere through respirator
33	23 Surrounded by fluid/water	56	23.1 Surrounded by fluid/water – work in or under water
		57	23.2 Surrounded by fluid/water – work nearby water

No	Storybuilder- number and name	No	Bow tie Model – number and name
34	25 Straining of muscles and joints	58	25.1 Straining of muscles and joints – when handling objects, peoples
		59	25.2 Straining of muscles and joints – with movement around
35	26 Too rapid pressure equalisation	-	-
36	27 Explosion	60	27.1 Physical explosion
		61	27.2.1 Chemical explosion – vapour or gas
		62	27.2.2 Chemical explosion - dust
		63	27.2.3 Chemical explosion – explosives
		64	27.2.4 Chemical explosion – exothermic reaction

Diagram 11. Shows an overview of the 36 story builders and 64 “bowties” that are compiled in the WORM project.

3.1.2 Storybuilder

Each of these 64 logical “bowties” are based upon knowledge from a large number of actual accidents, in all over 9000 accidents, which in a period over 6 years have been investigated by the Dutch authorities. In all cases there is talk of accidents where the injured person either is deceased or has been admitted to hospital as a result of the accident. In the Netherlands, all such accidents must be investigated in detail.

In order to gather information from all of these accidents, a so-called "story builder" was developed, which is a computer program where the critical event is identified and where both the right and left sides of the critical event are mapped for each concrete accident. In addition, there is information about safety barriers that have been lacking or that have failed, and a registration of the services in the management and organisation system that are associated with these deficiencies and errors, cf. figure 20.

Figure 22 illustrates an example of a “story builder” that shows, how a larger number of accidents with the same type of critical event (the yellow box) spreads itself out on different consequences to the right, and causes and deficient safety barriers to the left. The red lines indicate each course of an accident and its path through the system (RIVM 2008).

The details that are included in the Storybuilder diagram are the following:

- The work related situation
 - A – Activity at the time of the accident
 - ET – Type of aid
- Error and causes:
 - DS – Error in output from the management system
 - T – Barrier error (PUMM’s)
 - BFM - Barrier error (PSB og SSB)
 - IF – Influencing condition or factors (PIE’s)
 - LCE – Loss of control / deviating event
 - REG – Observance of legislation
- CE - Centre event/ critical event
- Effects:
 - DDF – Factor involving person causing the loss
 - INJP – The injured part of the body
 - INJT – Type of injury/diagnosis
 - HOSP – Scope of hospitalisation

- Consequences
 - FOD – Final consequence death
 - FOI – Final consequence likely recoverable injury
 - FOP – Final consequence likely to be permanent invalidity
 - ABS – Absence from work

Classifications from ESAW have been used, for example, for registering the type of aid, body part and type of injury.

Figure 22

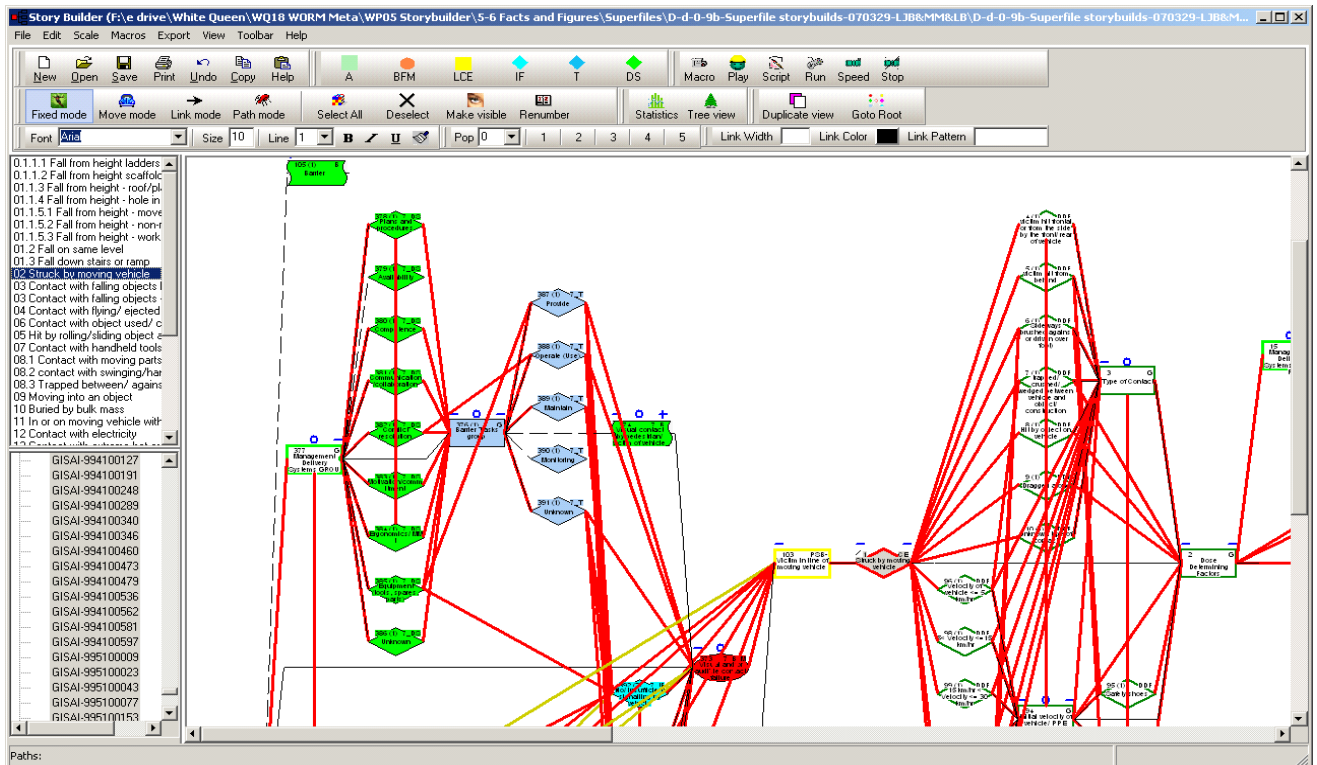


Figure 22 shows “the story builder interface” with an example of one of the 36 storybuilders.

3.1.3 PIE’s – Probability Influencing Entity

A significant element in the analyses in story builder and subsequent “bowties” is which safety barriers that have failed and have thus led to the accidents happening. In some cases the safety barriers are easy to assess, while in other cases they require more detailed information.

One example is the safety barriers that shall ensure that the support of a scaffolding is in order (PSB). Here, the safety is dependent upon the surface’s condition, the support’s surface and placement, presence of a spacing support and its distance (SSB) etc.

But, it is also necessary not only to identify that the safety barriers are in place but also their quality and which factors that have significance to this.

The factors that have an influence on the quality of the safety barriers, and that by that means have an influence on the likelihood of an accident occurring, have been given the designation PIEs. It stands for “Probability Influencing Entity”, that is to say factors that can influence the likelihood.

The philosophy is that if all PIEs are in complete order, then the safety barriers are too and therefore the risk of an accident is low. If some of these PIEs are faulty, not in order or not in place, then the safety barrier is bad and the risk of an accident is high.

For example, PIE questions for the base of a scaffold are the following:

- Control of the foundations supporting ability
- The foundation's strength in relation to weight and planeness
- Control of whether the foundation remains sufficient
- Use of wooden blocking to ensure stability
- Strength of the construction that the scaffolding is attached to
- Control of the construction's strength in relation to the scaffolding

Connection between these PIEs and safety barriers, and their significance to calculation of the final risk is illustrated in figure 23.

Figure 23

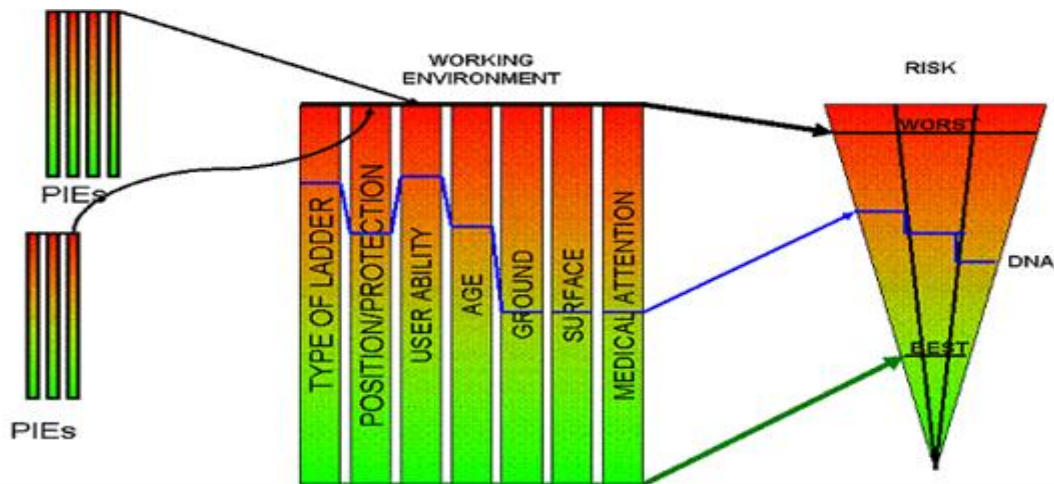


Figure 23 illustrates the connection between PIEs and safety barriers and the significance for the risk level in this case exemplified for “fall from ladder”.

The 7 designated conditions in “the working environment” are an expression for the 7 safety barriers that are identified as most significant in the analysis of the hazard “fall from ladder” (RIVM 2008)

Each of the safety barriers in all of the “bowties” have thus had a number of PIEs associated. It is, at the same time, the factors that are asked when the risk is assessed and calculated.

3.1.4 Preventative activities, efficiency and costs

The next step in expansion and use of the knowledge that is established through storybuilders, “bowties”, safety barriers and PIEs is to connect it to the activities that can ensure that PIEs are in order and to have evaluated what each of these activities costs.

The goal is that when one registers that the safety barriers are not in order, and registers which PIEs that have significance to this, one can also show which measures can improve the conditions and which measures are the most effective and what these cost. For this purpose, the following knowledge card index has been built up in WORM:

- A library over activities that can change the value of PIEs, that is to say, improve these conditions
- A detailed description of measures with reference to norms and standards
- The costs of these measures through a general evaluation of how such improvements are normally carried out and combined in a generic form.
- A list of the actions a measure requires, which form the connection between measures, PIEs and safety barriers.
- An evaluation of the effectiveness of each measure with regard to its potential for influencing and reducing the risk

This list of measures is in a mixture of generic, and for the individual “bowties” specific measures that strengthen the organisational, behavioural and technical safety barriers. The generic measures include, among others, training, inspection, physical safety barriers, control, signals and warnings, etc.

The sources of these measures are taken from established checklists, safety manuals, procedures, training schedules, required training, as well as European and Dutch norms and standards.

An example of the connection between “bowtie”, safety barriers, PIEs, PUMM’s, exposure information and measures is shown in diagram 12. Specified in the example is one safety barrier and one PIE for the sake of the overview.

Diagram 12

Bow tie	Falls from heights from a ladder
One of the safety barriers	Type and condition of the ladder
One of the PIE’s	Surface of the steps
The question in the survey	In what % of the time where you use a ladder, were the steps slippery because of the ladder type or the presence of e.g. paint, earth, snow, water, etc. on the ladder steps.
PIE action	Be sure that the steps on the ladder have a good foot grip
Measure	Use anti-slip treatment on the steps Ensure good maintenance and keep clean Carry out a visual inspection prior to use Periodic inspection and maintenance

Diagram 12 shows an example of the connection from the Bowtie analysis with respect to Safety barriers, PIE and measures, where only one example is specified from each step. (RIVM 2008)

An evaluation of the effectiveness of the measures and significance to the risk, concerning the measures effectiveness in relation to changing the PIE quality going from being unsuitable to being good. This assessment is difficult, and in the WORM project it is also recognised that neither in the literature, nor among the experts is there sufficient knowledge in the field. As an alternative, a qualified evaluation system for this effectiveness was developed. This system received two dimensions, each with 3 possible resulting values.

The two dimensions are:

1. The type of measure (source)
2. What the measure influences (area of influence)

Figure 24 shows the 2 dimensions and their respective 3 values. In addition, diagram 13 shows the percentages that are used for the individual measures evaluated effectiveness for their areas of influence.

Figure 24

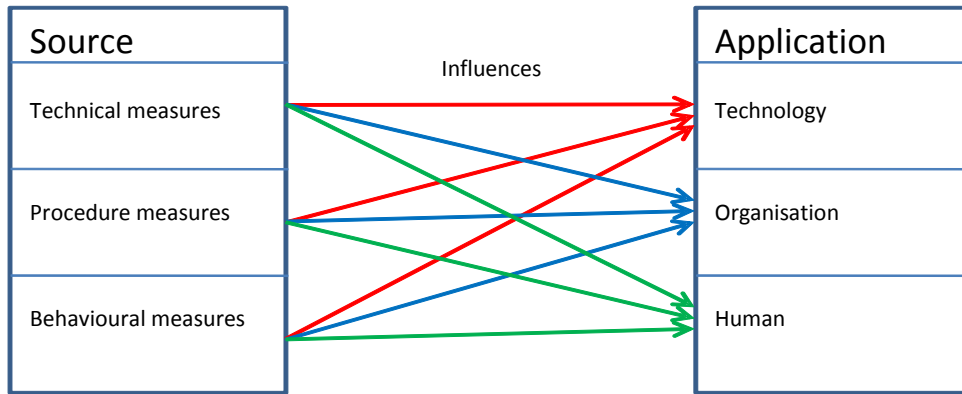


Figure 24 illustrates the basis for an effectiveness system for measures based upon 2 dimensions and these dimensions 3 values. (RIVM2008)

Diagram 13

	Area of influence	Physical conditions	Organisational conditions	Behavioural conditions
Source				
Technical measures		80 %	70 %	50 %
Procedural measures		60 %	60 %	50 %
Behaviour regulating measures		50 %	50 %	40 %

Diagram 13 shows the percentages used for evaluating the effectiveness of different types of measures effectiveness on different types of areas of influence (RIVM 2008)

It is also clear that each measure can influence more than one PIE, and that each PIE can be influenced by more than one measure. It is the quality of the PIEs that determines the quality of the safety barriers. Therefore, each measure has the ability to reduce an existing gap to the perfect. This is the goal for effectiveness.

One example is, that if it is registered that a PIE is on a negative level 40% of the time and the effectiveness of a measure in achieving a gap of 0 is 75%, this means that the PIE level is reduced by $(40\% \times 0.75) = 30\%$. Thus the new PIE value becomes $(40\% - 30\%) = 10\%$.

One example, where a PIE is "to detect hazardous substances in the atmosphere", and where a PIE level of 40% has been registered, i.e. that 40% of the time, people can be subjected to an exposure of hazardous substances in the atmosphere, because an observation system is not working.

The gap that shall be reduced is therefore 40%, for which measures shall be found to reduce this. If the effectiveness of a measure in combination with the action "to detect hazardous substances in the atmosphere" is evaluated at 75% e.g. through a technical aid

to measure the hazardous substances, then the gap will be reduced to 10%. A subsequent measure shall then be directed toward this 10% gap, which means that the gap can never achieve the value 0 (RIVM2008).

The evaluation of the costs of carrying out the individual measures is also difficult to determine. The matter is, that the measures will have different cost levels within different sized companies and company strategies and therefore be almost impossible to set correctly in relation to the individual concrete company. Therefore, the WORM project's basis has solely been:

- The most common implementations and the most common business characteristics within a certain industry are presented as standard
- Only the most relevant and direct costs are taken into consideration

The costs for a measure have a fixed share, which constitutes a first payment, and a variable share, which is based on an expected lifespan of the measure. Both parts can, in the developed software model, be adapted by a given user to an actual situation. All indirect costs, e.g. for production, wages and storage capacity, etc. are not included.

In this exercise, the WORM project has taken many different means into use in order to obtain a good basis for the financial calculations. Including the actual prices for purchases but also a large number of expert assessments of the cost levels for carrying out specific measures (RIVM2008).

3.1.5 Surveys on exposure data

In order to be able to limit a risk, two sets of data are necessary:

1. A likelihood that a critical event can occur with consequences resulting from this
2. A knowledge of the exposure of the person to the given critical event and the working conditions in which these exposures are included.

With regard to the first set of data, namely calculation of the likelihood of a given critical event occurring, there is the need for:

1. A numerator, which corresponds to the number of observed cases of critical events and their consequences
2. A denominator, which is the total number times persons are subjected to a situation, where the critical event can occur, i.e. the time with which the person is exposed for a given hazard.

For example, the risk of falling down from a scaffold will be able to be calculated based upon details of a numerator, that indicated the total number of accidents with falls from scaffolding and a denominator, which indicates the total working hours, that have been spent working on a scaffolding. In addition this risk can be increased or reduced depending on the conditions under which the work is carried out.

In order to be able to calculate the likelihoods, the WORM project carried out a comprehensive survey, which mapped out the exposure conditions in The Netherlands. This survey was carried out in 2 phases, where:

- The first phase mapped out how many workers in The Netherlands were exposed to the 64 hazards,

- The second phase was comprised of separate surveys for each of the 64 hazards with regard to mapping out the working conditions and the presence/lack of PIEs.

Figure 25 illustrates the structure of the two phases of this comprehensive survey that was based on an Internet survey among 30,000 workers in The Netherlands. The first phase of this survey was named “the mission survey”. Its purpose was to map out the number of hours, the Dutch workers were subjected to the different forms of hazards. An example of mapping of exposure for one type of hazard from the RIVM 2008 report is the following:

Exposure for the hazard “being struck by a moving vehicle”. Here, the exposure will be the number of hours where a worker remains in areas in association with his work, where there are moving vehicles. This applies, among others, to activities in all industrial areas where there, at the same time, is carried out moving transport, in warehouses with mobile transport, along public roads e.g. in association with road works, rubbish collection, the delivery of goods, etc. Actual traffic activities, that involve traffic accidents are not included, as such accidents are not counted as workplace accidents in The Netherlands.

In this survey, it was asked how many hours the individual was in the work situations subjected to each of the 64 hazards within the past week. Thereafter, these details were extrapolated to an annual exposure based upon 42 working weeks per year. In addition to these exposure details, basic data was also collected on industries, job, age and sex. This has formed the basis for descriptions of the risks the Dutch workers are subjected to in different jobs and industries.

Figure 25

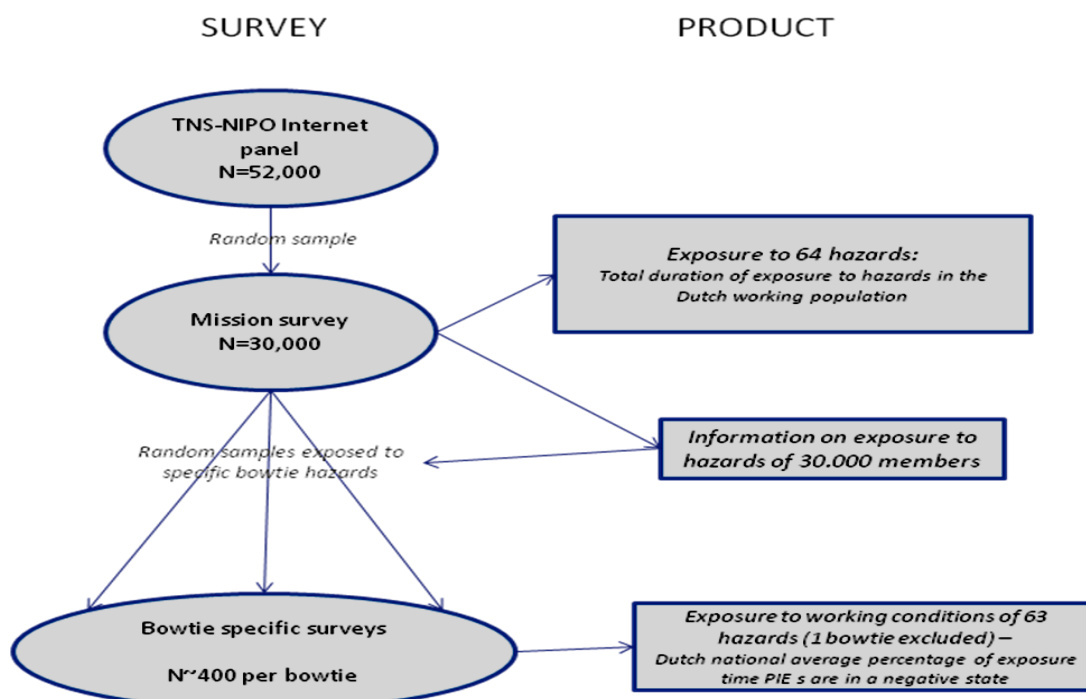


Figure 25 illustrates the survey structure in the WORM project's collection of exposure data for use in calculating the likelihoods (RIVM 2008)

The second phase of the survey received the designation “bowtie specific survey”. In this second phase, 64 specific surveys were carried out, one for each hazard. The purpose of this second part was to map out the working conditions that have significance to whether the risk is high or low, i.e. a mapping out of the presence of the specific PIEs linked to the

safety barriers. An example of the questions for one type of hazard and one type of safety barrier are the following (RIVM 2008):

Three PIE questions are formulated for the hazard “Struck by a moving vehicle” where one of the safety barriers concerns “location and placement of the worker in relation to the moving vehicles”:

- 1. The measures that separate pedestrians and the moving vehicles,*
- 2. The use of these measures,*
- 3. To what degree one passes close by, in front of or behind the vehicles.*

These specific surveys were carried out among the persons, who in the first survey responded that they were subjected to the concrete hazard during working hours, i.e. only persons were asked who were exposed. In each of these specific surveys, 400 people participated.

The question structure of the individual questions is illustrated by the following example (RIVM 2008):

The screenshot shows a software window titled "NIPD Interview System: NIPDM". Below the title bar is a menu bar with "Actions", "View", and "Help". There are two buttons, "OK" and "Back".

Question 1:
When you in the last 12 months were a pedestrian during your work in places where vehicles were moving.....

In what percentage of the time were the vehicles difficult to discern because they for example didn't have any lighting, didn't use sound signals when driving backwards, didn't use direction indicators

Below the text is a horizontal percentage scale from 0% to 100% in increments of 10%. Above the scale, "Never" is aligned with 0%, "Half the time" with 50%, and "Always" with 100%. The scale is currently empty, with no selection made.

After a number of quality and validation checks a sort of average was calculated for each PIE weighted with the details for the exposure data from the first “mission” survey. This average was used to quantify the risk factor in the ORM software program. With respect to details of all questions and calculation methods refer to the WORM reports.

3.1.6 ORM – The Occupational Risk Model

The purpose of the WORM project was to develop a software program that companies can use to:

1. calculate the company's risk for accidents
2. calculate the financial costs that can decrease this risk.

At the same time, with this, to be able to state which measures decrease the risk most in the most financially profitable manner.

The components, which are included in the development of this quantified risk model, are collectively shown in figure 26 (RIVM 2008):

ORM's logical model is the central part in the ORM software model and contains the analysis from “bowties”, including the connection between the safety barriers, PIEs and management services on the one hand and consequences on the other hand, which are gone over in sections 3.1.1, 3.1.2 and 3.1.3.. Linked to this are the denominator details from the two-phased surveys, which are described in section 3.1.5.

Behind the model and the calculations lies a highly comprehensive statistical program, which is carried out by NCSR Demokritos, Greece.

Figure 26

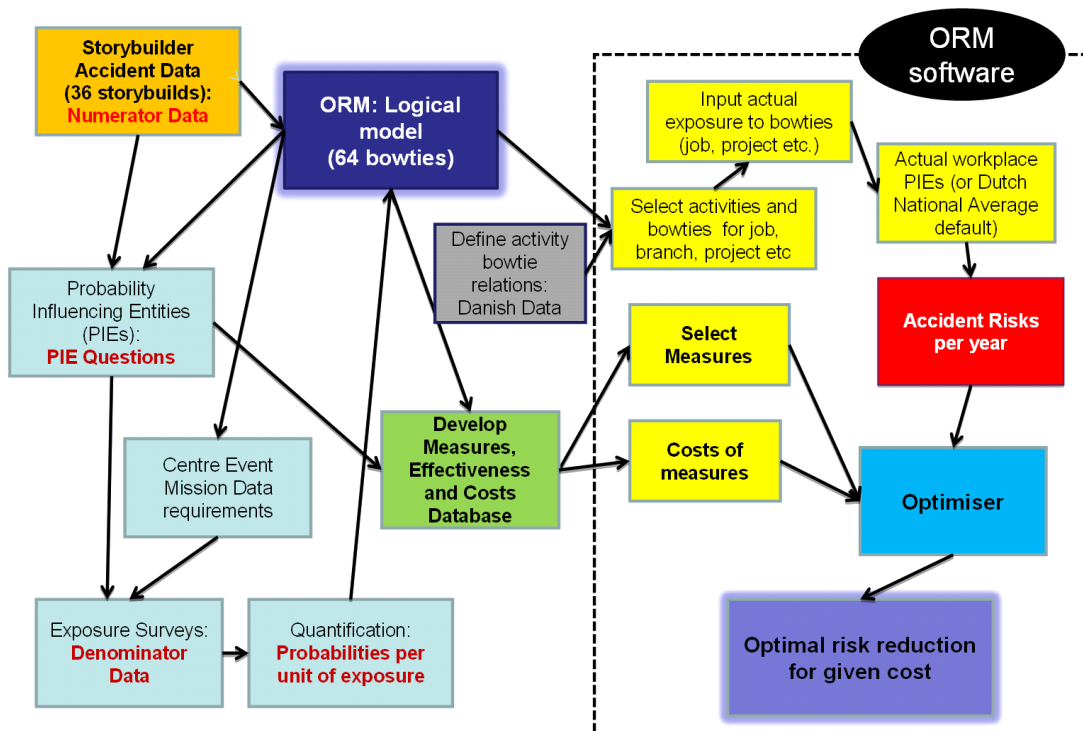


Figure 26 illustrates the overriding model for the data included in the ORM software model (RIVM 2008)

The developed software program is designed in such a way that if a company, workplace or trade group goes in and describes:

1. What they or the employee does and how long time (exposure times per “bowtie”)
2. Under which conditions this work is carried out (occurrence of PIEs)

so they can obtain a calculation of their risk of accidents that lead to either death, invalidity or recoverable with severe injuries.

The program can also conduct an optimisation (the optimiser), where it goes through the answers that are given about the working conditions and relates these answers to possible measures that can change the risk. At the same time this optimisation puts the measures into a financial evaluation of the costs of carrying out the measure.

An end product would be a picture, as shown in figure 27, where the 3 curves show respectively the risks for death, invalidity and reversible injuries. The curve's start point on the X axis states the risk that is present based upon the given details.

The X axis states the risk, while the Y axis states the financial costs of carrying out the stated measures. To the right of the image are specified the measures that "the optimiser" has found to be relevant based upon the information given about the actual exposures and working conditions.

By going into the individual points on the curves, one will be told which combination of measures must be carried out before one can reach this new risk level, and what the costs will be to carry them out.

Figure 27

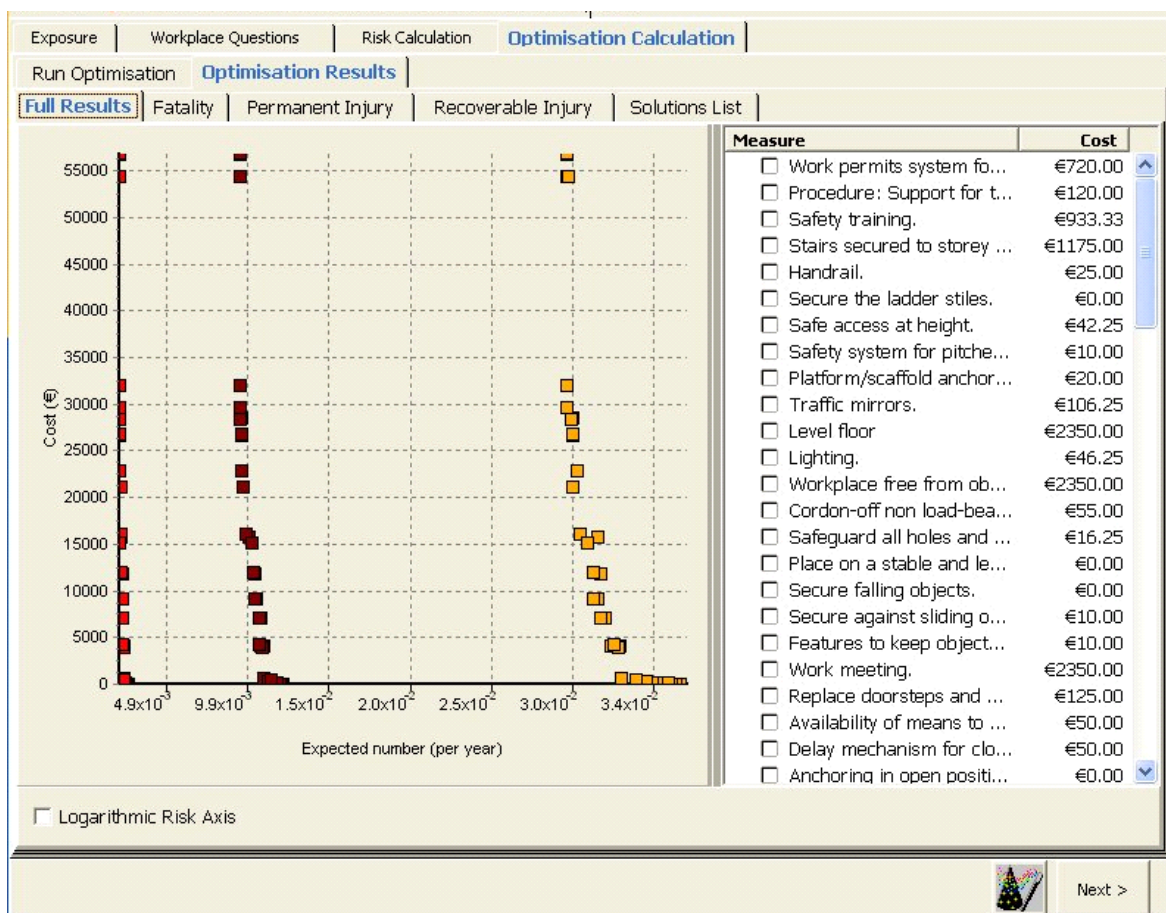


Figure 27 illustrates the ORM software end product with a statement of the risk for respectively death, invalidity and recoverable serious injuries after accidents, as well as which measures can decrease this risk and the costs of this.

With this, a good basis should be created for a company to decide which initiatives they want to carry out and what they can expect to get out of it.

The matter is, however, that quite a lot of data must be entered into ORM in order for these calculations to be carried out and the end product received.

All employees are subjected to risks in their work to differing degrees. These risks also include, as a rule, a number of different hazards / critical events. In the ORM program there is the potential for a company to specify a number of different jobs and also the number of employees that perform them.

For each job or task, one must also state which activities are carried out in relation to different types of exposures. E.g. if one is a carpenter then one must state how much time one spends going on ladders, on scaffolding, on roofs, in areas where vehicles are driven, etc. These details correspond completely to the questions that were asked in the 1st phase of the mission survey.

The next step in the software program is to inform about the conditions, under which each individual activity is performed, i.e. at which level the different

PIEs are present in the use, maintenance and control, etc. In the program, the “Dutch National Average” is inserted, so that you can either chose to “do as the average”, or chose to “specify/change all of parts of the stated PIEs”.

Figure 28

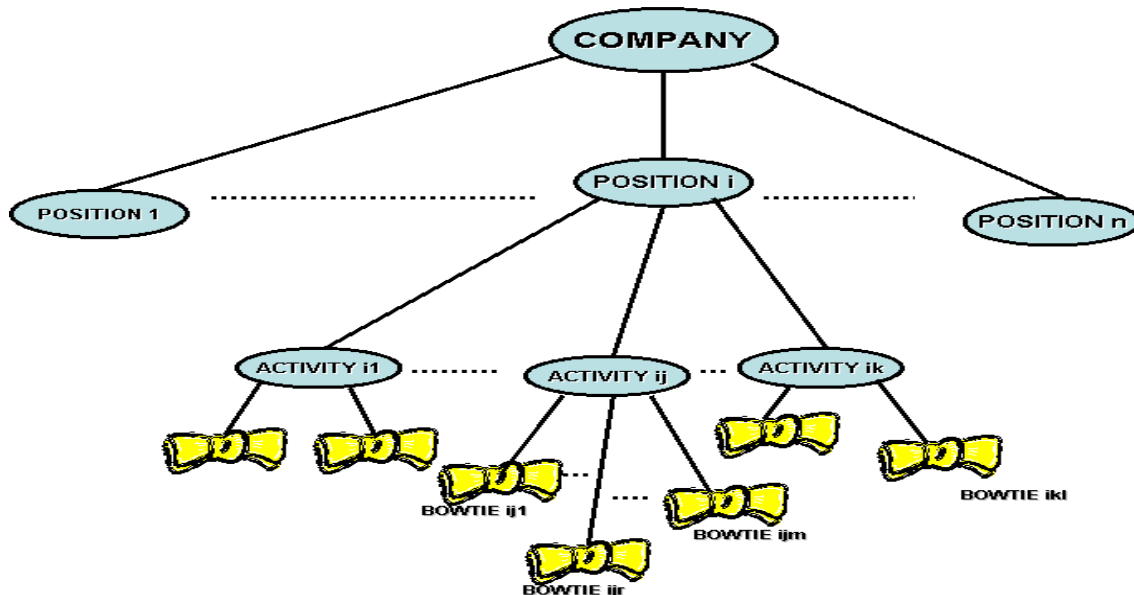


Figure 28 illustrates the structure of the details a company needs to provide in order to receive a calculation of the total risk.

Figure 29 then illustrates how the question about the individual PIEs is included, and where in the model the optimisation goes in and calculates where risk-reducing measures

can occur cf. section 3.1.3.

Figure 29

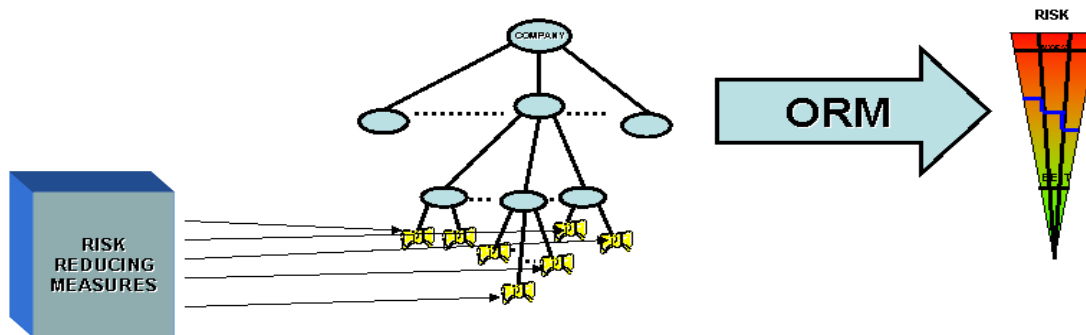


Figure 29 illustrates how changes of PIEs affect the risk calculation.

The Dutch ORM program has undergone a number of development steps and is now made publicly available in 2010, both in a stand-alone application and in a light web version cf. <http://weborca.nl>

3.1.7 Sensitivity analysis

Instead of using “The optimiser” to calculate concrete results of particular measures, that lead to results as shown in Fig. 27, one can also see what effect a change in safety barriers or PIEs has on the accident risk. To that a systematic analysis has been conducted where each safety barrier and each PIE are changed from the Dutch average (DNA) to the maximum (most optimal) value and its minimal value. Under the assumption that the other safety barriers or PIEs do not change, one can calculate how great a significance the individual barriers and PIE have on the risk. This is also a way of identifying which factors have the greatest influence, i.e. which factors one shall, with advantage, focus on in order to have the most security for the effort.

The analysis has looked at the primary and secondary safety barriers and at PIEs. The analysis has led to three parameters for each variable (safety barriers or PIE). The first two parameters (“Risk Reduction Index” and “Risk Increase Index”) are the percentage change in the risk (per exposed hour) if the safety barrier or PIE shifts from the Dutch average (DNA) to respectively, the maximum positive value (for “Risk Reduction Index”: the barrier is always in a good state or the PIE is 100% of the time in the positive state) or to the maximum negative value (for “Risk Increase Index”: the barrier is absent or PIE is 100% of the time in the negative state).

It is clear that these two parameters depend both on the effect of the safety barrier or PIE at risk, but also which improvement possibilities there are, in other words how the Dutch average is in relation to the optimum state.

The third parameter is the relative change of risk as a result of a change in safety barriers or PIE state. It gives a sort of “sensitivity” of the risk of changes in the safety barriers or PIE quality, which is not quite so dependent on whether the starting situation corresponds to DNA. That is to say, that this sensitivity can also be used as an aid for prioritising, when the relevant PIE does not correspond to the DNA. This sensitivity can be defined as: Changes in the bowtie risk/Changes in PIE.

$$\frac{\Delta \text{endringer i Bowtie} - \text{risiko}}{\Delta \text{endringer i PIE}}$$

The following figures show examples of these sensitivities.

Figure 30 shows an example of the “Risk Increase Index” and “Risk Reduction Index” for safety barriers in the “bowtie” “Struck by moving parts of machinery during operation”. The three consequences are differentiated, namely severe but recoverable injuries, permanent injury/invalidity and death.

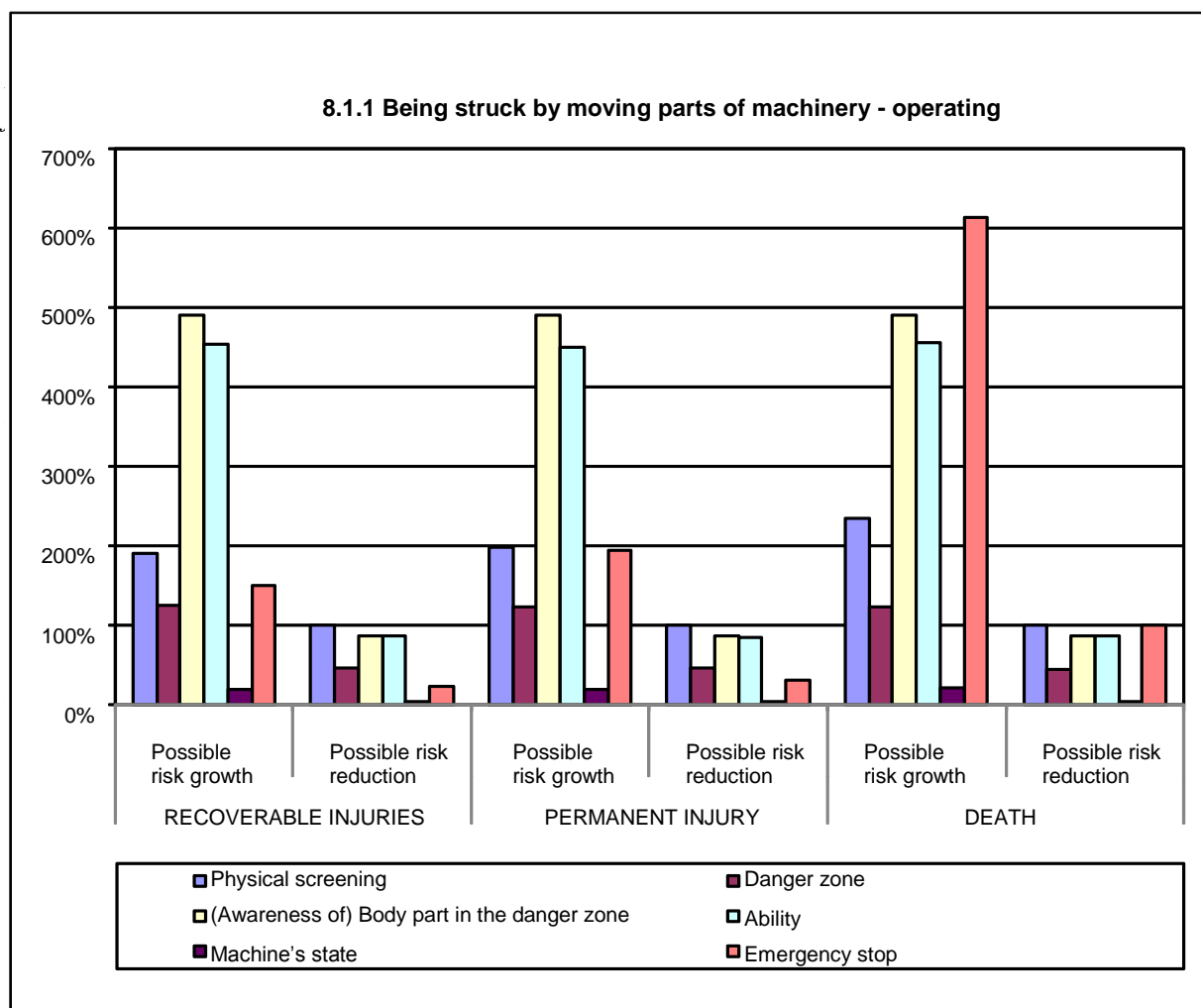


Figure 30 shows an example of the “Risk Increase Index” and “Risk Reduction Index” for safety barriers in the “bowtie” “Struck by moving machine parts during operation”.

Stated for each of these 3 consequences are the potential, percentual change in the risk, when the likelihood for failure of one of the six safety barriers changes from what, in WORM project, is the Dutch national average (DNA). The changes can go from 100% failure (“risk growth”) to 0% failure (“risk reduction”).

This figure shows, among others, that the sensitivity can be dependent upon the consequences, for example, the safety barrier “Emergency stop” on a manned machine is far more important to the death risk than to minor injuries. It can also be seen that the basis presupposes most of the safety barriers are “on the correct side” which means that the potential for improvement is fairly modest for several safety barriers, while the lack of a safety barrier can worsen the risk dramatically.

Figure 31 shows the sensitivity for the same hazard as figure 30. The trend is in agreement with figure 30, but the potential for improvement or worsening cannot be seen here. The figure illustrates instead, how the risk of “being struck by moving parts of machinery during operation” changes when the likelihood of failure of one of the hazard’s six safety barriers changes. It is noted that the calculations presuppose that all the other safety barriers have a failure likelihood in agreement with DNA.

Figure 31

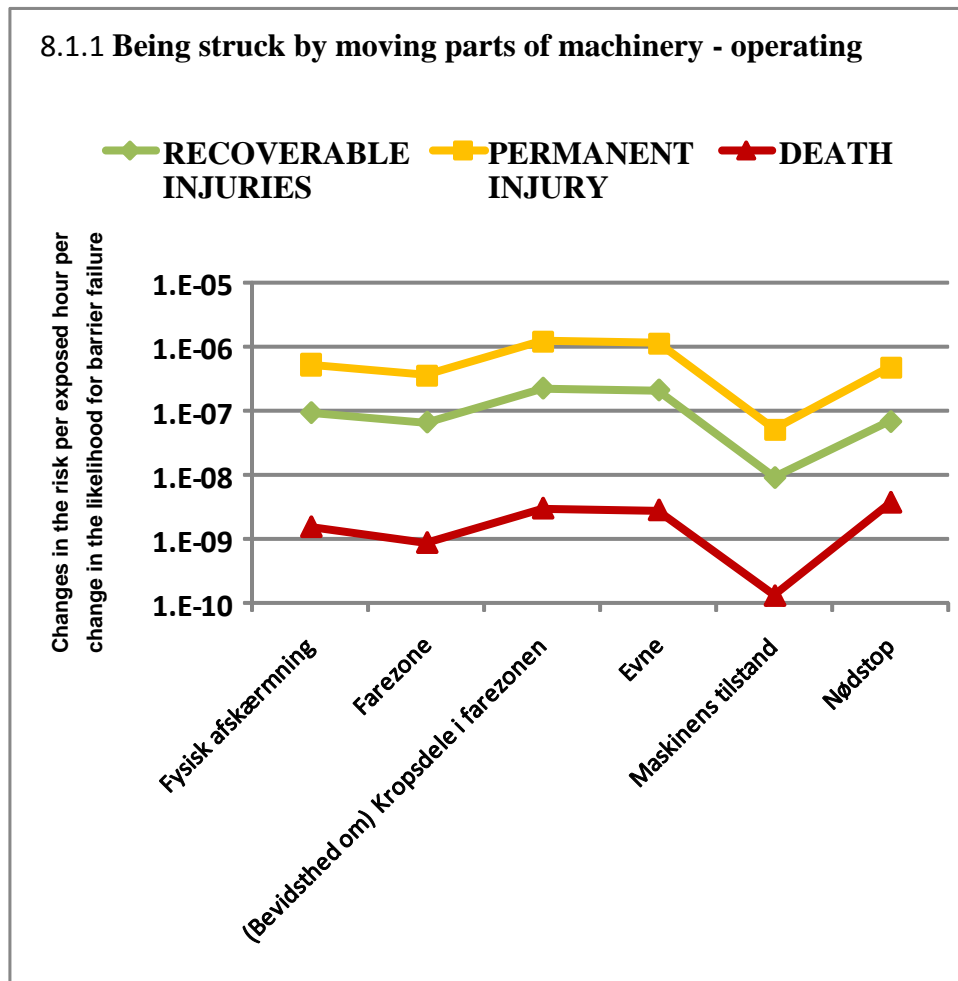


Figure 31 shows how the risk for “being struck by moving parts of machinery during operation” changes when the likelihood of failure of one of the “bowties” six safety barriers changes.

Figure 32 shows the sensitivity of the risk as a result of the changes in PIEs for the given hazard.

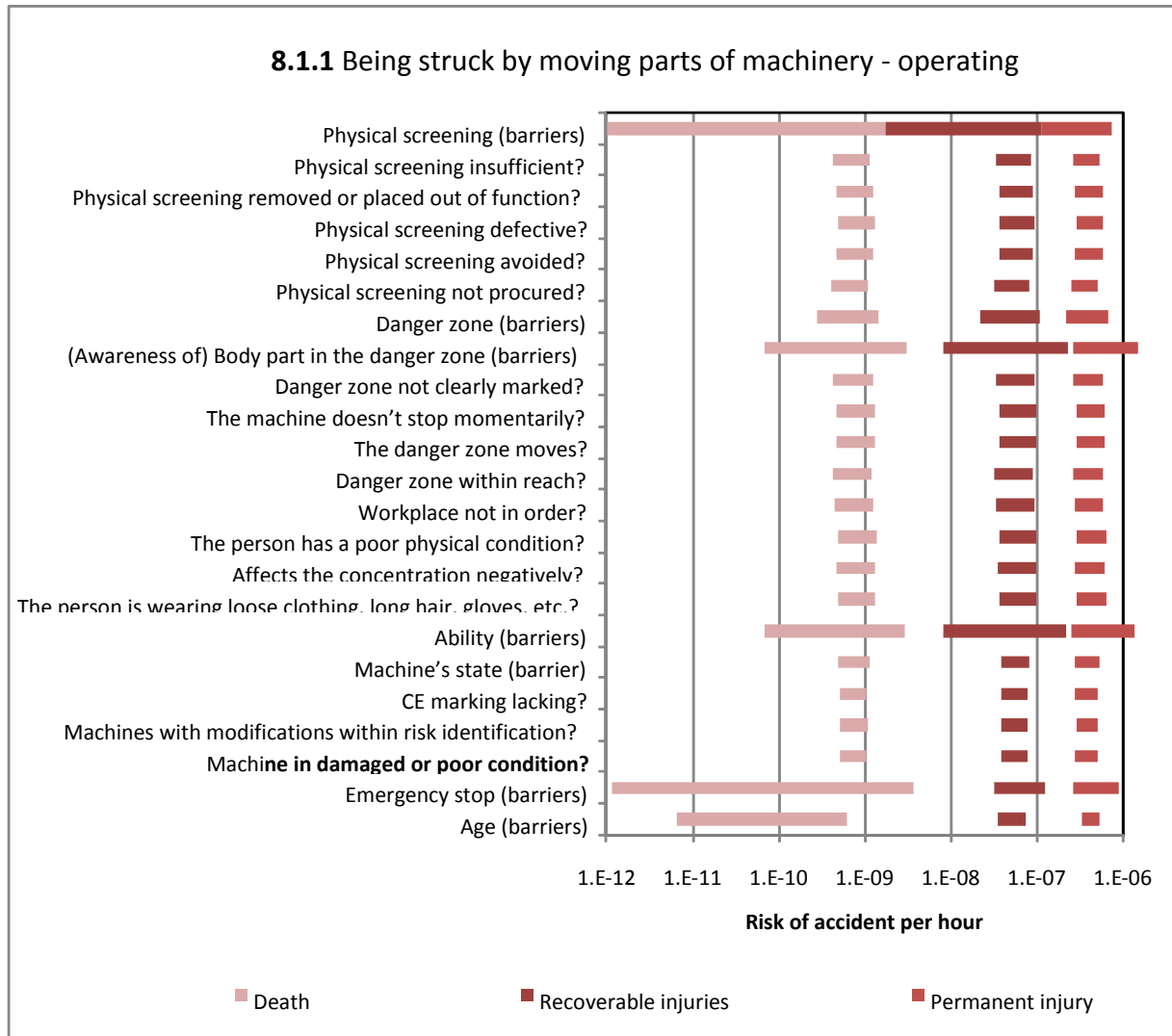


Figure 32 shows sensitivity of risk as a result of changes in PIEs.

The figure shows the intervals for risks, when the PIE concerned is changed from the most positive to the most negative state in relation to DNA. Additional PIEs that influence a barrier and thereby the risk intervals are also shown.

3.2 General results from WORM

In addition to the developed software for use in the risk calculation and risk optimisation, there is comprehensive data material in the entire WORM project that can be used in general. Also drawn up is a large number of analyses and reports over the data that the material contains, and an actual data warehouse with the possibility of pulling data out in all directions.

Here is five examples of the analyses, the material gives the opportunity for:

1. An overview of the relative risk for the 3 types of consequences for the 64 "bowties".

2. An example of the meaning of Barrier error in association with the risk of fall from roof
3. An example of the 10 most important Barrier errors that shall be checked when building, and which underlying errors and managerial errors that are associated with this.
4. An overview over the distribution of errors in the managerial output for all “bowties”.
5. Examples of different analyses of exposure data from the surveys carried out

3.2.1 The relative risk for 64 “bowties”

The number of accidents per year per 100,000 employees gives a value that is an expression for the national average risk per year in The Netherlands. The following 3 figures show this relative risk for, respectively, death, invalidity and recoverable severe injuries with a rank order of the 64 hazards according to the risk value's size. (RIVM 2008)

Figure 33 shows a rank order of the 64 hazards based upon the likelihood of a fatal accident per year, with an average exposure evaluated on the basis of the Dutch national average (DNA). Thus “Fall from roof” contains the greatest likelihood of leading to a fatality, etc.

Figure 34 shows a corresponding rank order of the 64 hazards based upon the likelihood of an accident involving invalidity per year, with an average exposure evaluated on the basis of the Dutch national average (DNA). The hazard with the highest likelihood per year is “contact with moving machine part during cleaning”, just as it is the hazard with the highest likelihood per exposed hour, while the hazard with the highest number of accidents that has led to invalidity is “contact with moving machine part while working with the machine.

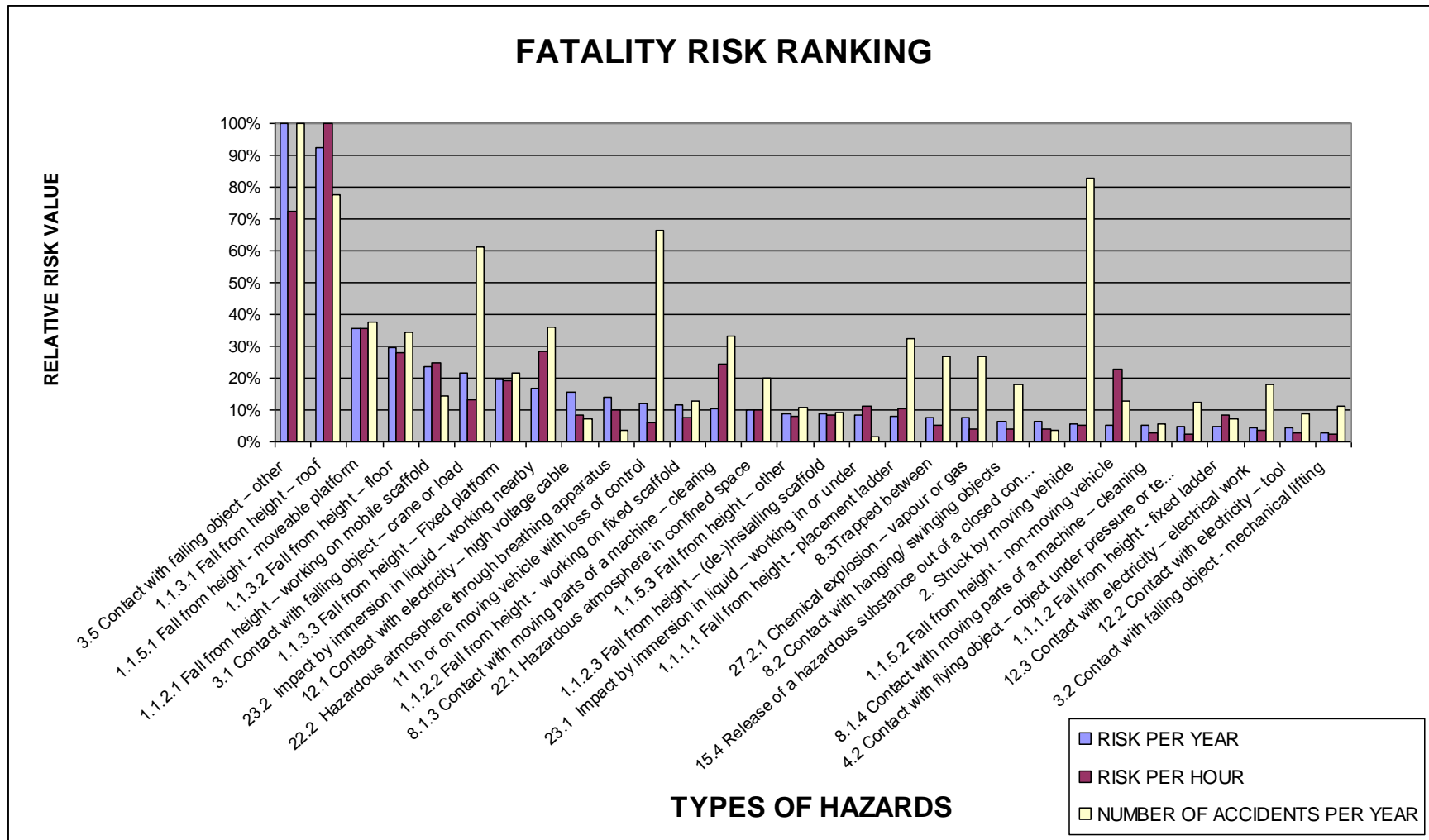


Figure 33 shows the 64 hazards ranked after which contains the greatest risk of fatality by accidents per year.

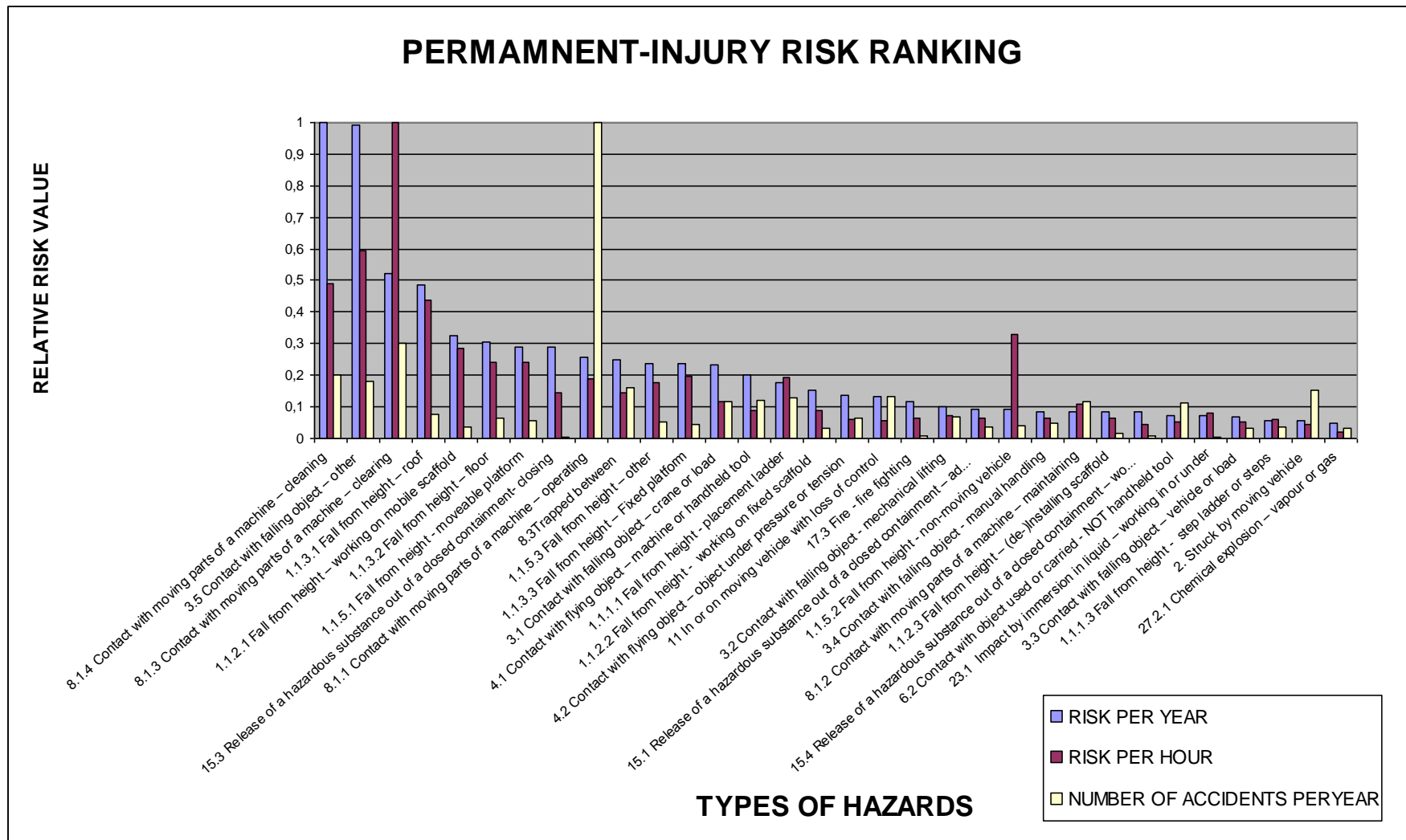


Figure 34 shows the 64 hazards ranked after which contains the greatest risk of invalidity by accidents per year.



Figure 35 shows the 64 hazards ranked after which contains the greatest risk of accidents per year that leads to severe but recoverable injuries

3.2.2 Barrier faults in connection with the risk of falling from roofs

In order to gain an impression of what details that can, for example, be retrieved for specific risks, the following 2 diagrams are shown. Diagram 14 illustrates which safety barriers that have failed in association with accidents involving “fall from roof”, and in what scope these safety barriers have failed with all inspected accidents of this type.

BARRIER FAILURE MODE	Description	% of roof fall accidents	Nr. Accidents 1998 – Feb 2004	Nr. Per Year
CAUSES OF FALL				
Roof edge protection failure	(Temporary) guard rail failure, edge protection is absent, insufficient or has been removed. NB: Includes edge protection on perimeter and alongside openings holes, ducts, skylights and roof access (e.g.: roof shutters). NB: a window or door in a wall along a floor is also considered edge protection!	45.1%	496	80
User Ability Failure	Skill - balance - to stay on roof/floor/platform fails	27.8%	306	50
Roof/working platform/floor (parts) not intended to support exerted weight	Parts include skylights, roof gutters, vent holes not designed to bear weights.	22.6%	248	40
(Part of) Roof/floor deficient condition	Structural deficiency or parts of floor, roofs, ceilings are substandard (e.g. in bad condition or unstable)	13.9%	153	25
EMERGENCY RESPONSE				
Fall arrest failure	No (use of) fall arrestors or safety nets. Includes cases where harnesses were worn, but no safety line was attached.	24.8%	273	44
No (adequate) emergency response		1.8%	20	3

Diagram 14 illustrates an example of failure in the safety barriers, which are the most important causes of accidents involving a fall from roof (RIVM 2008)

Diagram 15 follows up on the results in diagram 14 and shows the most common fault in PUMM's i.e. the conditions that shall ensure that the safety barriers are in order and the faults that are found in the managerial measures that shall ensure that the conditions are in order. Diagram 15 solely concerns, just as diagram 14, the accidents that are linked to the hazard “fall from roof”.

Underlying failure	Description	% of accidents	Nr. Accidents 1998-Feb 2004	Nr. Per year
Barrier task failure				
Provide edge protection	Failure to provide edge protection (absent 22%, incomplete/insufficient 6%)	31.7%	348	56
Provide fall arrest	Failure to provide adequate fall arrest (mostly absent)	14.8%	163	26
Provide roof strength	Failure to provide sufficient roof/floor/platform strength to support weight	9.8%	108	18
Use ability to keep balanced	Failure by victim to keep their balance on the height (4% due to slips/trips, 1% due to external force)	9.1%	100	16
Delivery system failure				
Plans and procedures for edge protection	Inadequate or no plans and procedures for edge protection: - for providing edge protection (11.5%), for using edge protection (1.3%), for maintaining edge protection (1%) and for monitoring edge protection (0.2%)	14.0%	154	25
Motivation to ensure user able to keep balanced	Insufficient motivation or commitment to the user keeping their balance when using the roof/floor/platform (5%), to ensuring that keeping balance is possible (2%), or to the maintenance of means to keep balanced (1%)	8.7%	96	16
Motivation/commitment for edge protection	Insufficient motivation or commitment to ensuring adequate edge protection is provided (4%), used (1.4%), maintained (1.4%), and monitored (0.2%)	7.0%	77	12
Plans and procedures for fall arrest	Inadequate or no plans and procedures for providing (4.9%), using (1.3%), maintaining (0.3%) or monitoring (0.3%) fall arrest	6.8%	75	12

Diagram 15 illustrates an example of the errors in safety conditions and managerial measures that would have ensured that the safety barriers were in order, but that have involved accidents by fall from roof. (RIVM 2008)

3.2.3 The 10 most important barrier faults when building

By an analysis on industry level of all accidents within building, one can find those errors in safety barriers that have the greatest significance to the risk in this industry. Listed in diagram 16 are the 10 types of safety barriers, which there especially should occur a safeguard of:

Diagram 16

The safety barriers are underlined under each of the following points:

- Presence of correct railings along the roof, ground and platform.
- **Placement of ladders** – if the conditions are suited to placement of a ladder, if the ladder has a sufficient length, is placed on stable and firm foundation with a safe angle, and secured against movement.
- Procure and use personal fall protection, when working at heights without railings.
- Attention to the building parts being properly secured.
- **To keep people outside of danger zones** where loads are hanging or where there is the danger that objects can fall down from heights, like under object that are being mounted.
- **Safe cutting of loads**.
- The presence of proper railings on scaffolding and monitoring of control measures, which ensure that the railings remain in good order.
- **Proper construction of the scaffolding** (especially support and anchoring) and state of the scaffolding floors (e.g. fixing to the building).
- Presence of reliable machine guards and sufficient user ability to operate the machines in a safe manner.
- Check that current-carrying parts are not live when working with them, including measures to ensure that they remain so during the entire work (lock-out).

Diagram 16 shoes the top 10 themes for use in safety checks within building (RIVM 2008)

Also linked to these faults in the safety barrier is knowledge of the scope of errors in the underlying causes (PUMM's) and errors in the management's measures. Diagram 17 shows in which scope these conditions have had significance to errors in the safety barriers for the building sector in total.

Diagram 17

Also linked to the safety barrier errors specified in diagram 16, is a broad significance of the underlying causes (PUMM's) and errors in the management's measures. Stated below is the significance of the underlying causes for the safety barriers in the building and installation sector:

*(1) Error in the task related safety barriers (PUMM's = the Provide, Use, Maintain, Monitor tasks)
cf. figure 20*

- Barrier not procured: 47%
- Barrier not used or not used correctly: 39%
- Barrier not maintained in a good state or not secured so it remains in its place.: 8%
- No monitoring of whether the barrier is in place: 6%

(2) Error in the services, which the management system shall offer in order to secure the task related safety barriers

(the underlined words refer to designations in the management system, as stated in figure 20)

- Insufficient motivation and attention from management: 30%
- Insufficient plans and procedures: 16%
- Insufficient or unsuitable equipment: 15%
- Insufficient staff competencies: 11%
- Insufficient communication: 10%
- Insufficient solutions surrounding conflict between task and safety: 10%
- Poor ergonomic furnishing and design in the work: 6%
- Insufficient access to the appropriate staff: 2%

Diagram 17 illustrates the significance of errors in the underlying causes of accidents in the building sector (RIVM 2008)

3.2.4 Distribution of errors in the managerial measures

It is also interesting to highlight what the significance of the individual elements in errors of managerial measures are to the risk of accidents. Here it shows that there actually is a difference in

the different types of risks but that there are also some measures that are more important than others to place focus on.

Figure 36 shows the general division of the errors in measures, which are registered for all the analysed accidents. The curves also illustrate how this distribution looks for 5 different specific hazards. For example, the ergonomic design of hand tools is a significant defect for accidents using hand tools, while the explosion risk has defects on the delivery of the correct technical equipment. On the general level comes management's lack of ability to motivate safe behaviour in at a clear first place.

Figure 36

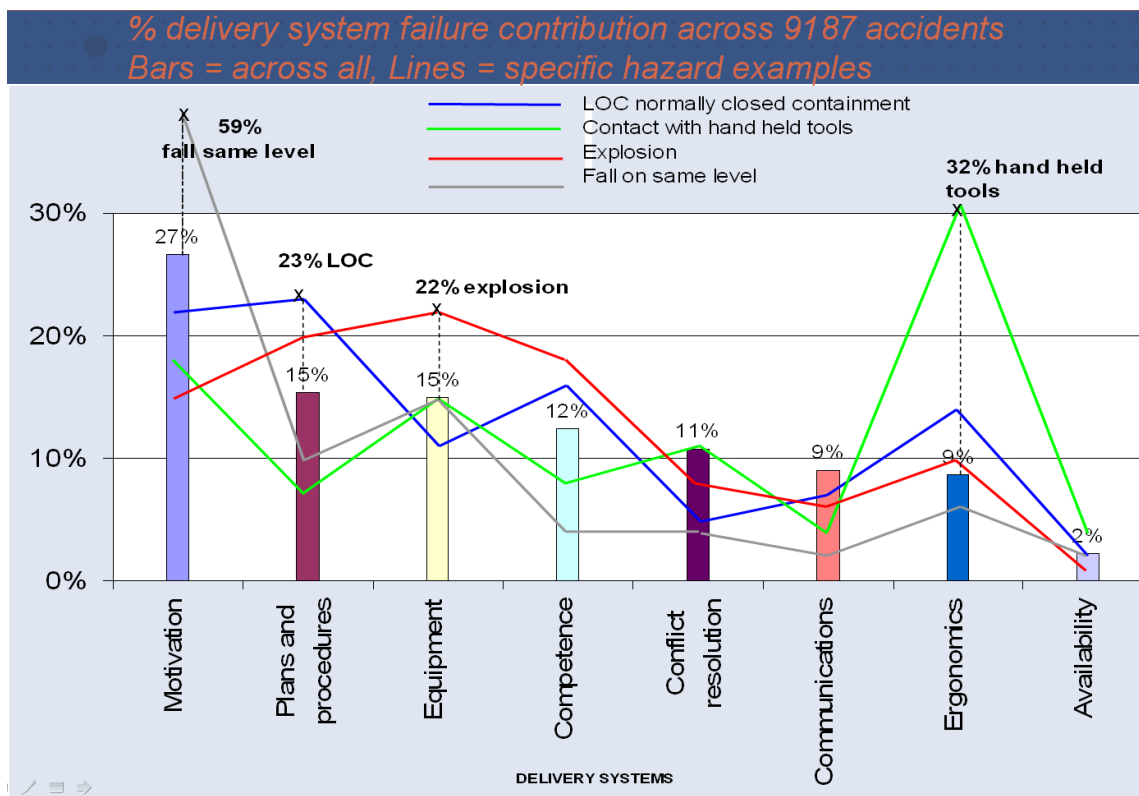


Figure illustrates faults in the management services both generally and for 5 specific risks (RIVM 2008)

3.2.5 Examples of analyses of exposure data

This Dutch survey of exposures to accident risk is unique and gives, for the first time, the opportunity to set a number of accidents in relation to the scope of exposure, which occurs in the ORM software model. But in addition to this, the collected data also provides the opportunity to describe not only what risks people are subjected to but also precisely the scope of the exposure in different industries, jobs, task types, and under which conditions these risks occur.

In the Dutch report (RIVM 2008) the following examples are given for what this data can show. The DanWorm project has, to a certain extent, taken a point of departure in that the difference between the Dutch and Danish workplaces do not differ significantly from each other.

The first example of the use of exposure data is figure 37, where it is shown how many employees are subjected to being struck by a vehicle. The figure shows the number of employees distributed by the number of hours per year they are subjected to this exposure. As one can see, very many

employees are subjected to the danger in shorter periods, while a smaller number are subjected for a longer period of time. This type of distribution is quite typical for most of the types of hazards.

Figure 37

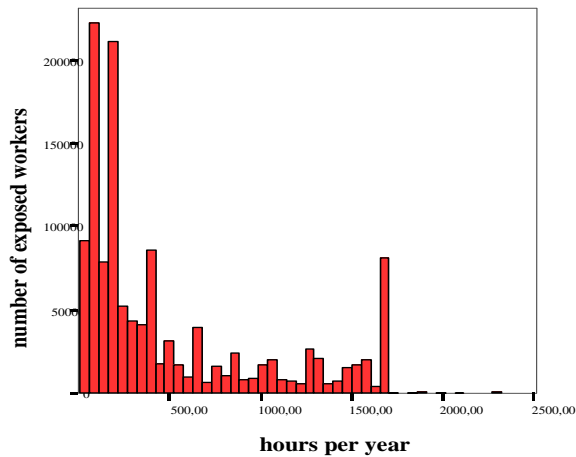


Figure 37 shows the number of employees who are exposed to the hazard "being struck by a vehicle" and the number of hours they are exposed. (RIVM 2008)

The second example is shown in figure 38 and is the result of an analysis of the 10 types of hazards that the Dutch employees are most exposed to measured in the number of hours per year.

Figure 38

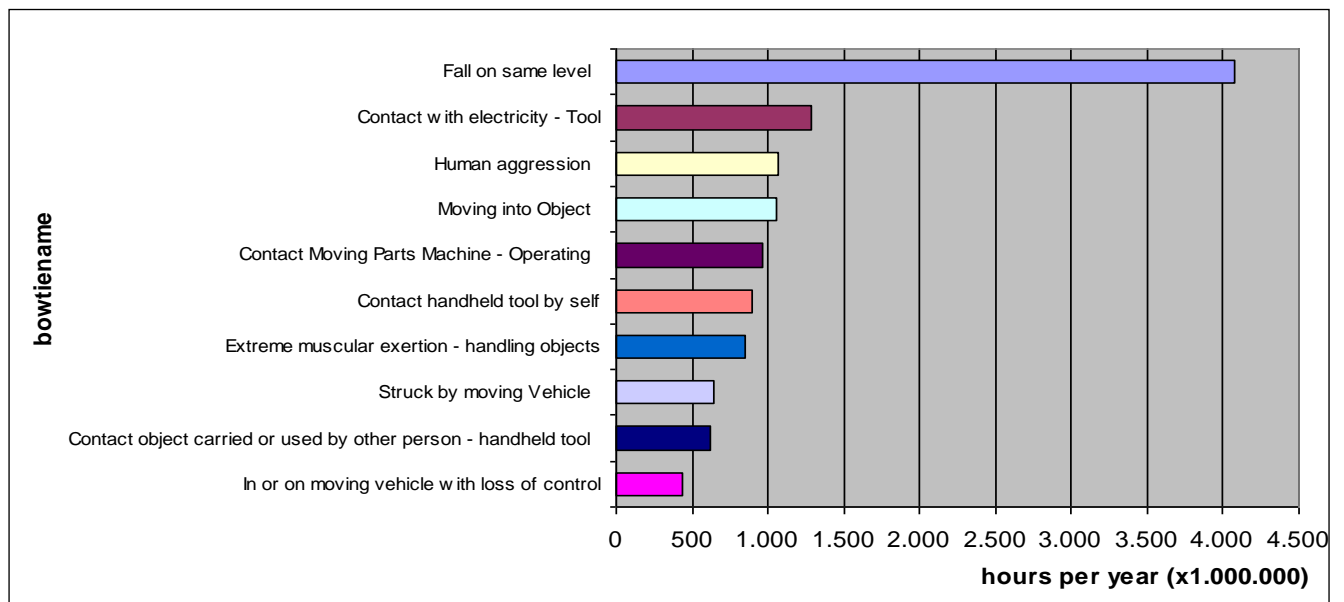


Figure 38 shows the 10 types of hazards, which Dutch employees are most subjected to measured in hours per year (RIVM 2008)

It is not surprising that the danger of falling on the same level, which concerns all forms of activities on the floor and in areas without a difference in heights is comprehensive, but there is also

many that are subjected to this hazard in a large part of their working hours. This means that the calculated risk, i.e. the number of accidents per number of subjected hours, remains small.

The third example is shown in figure 39, where the exposure to the hazard “struck by a vehicle” is divided into industries. Be aware that the traffic risk on public roads is not included in the Dutch data. The industry sector and the trade sector are the industries, where the employees are most exposed to this hazard.

Figure 39

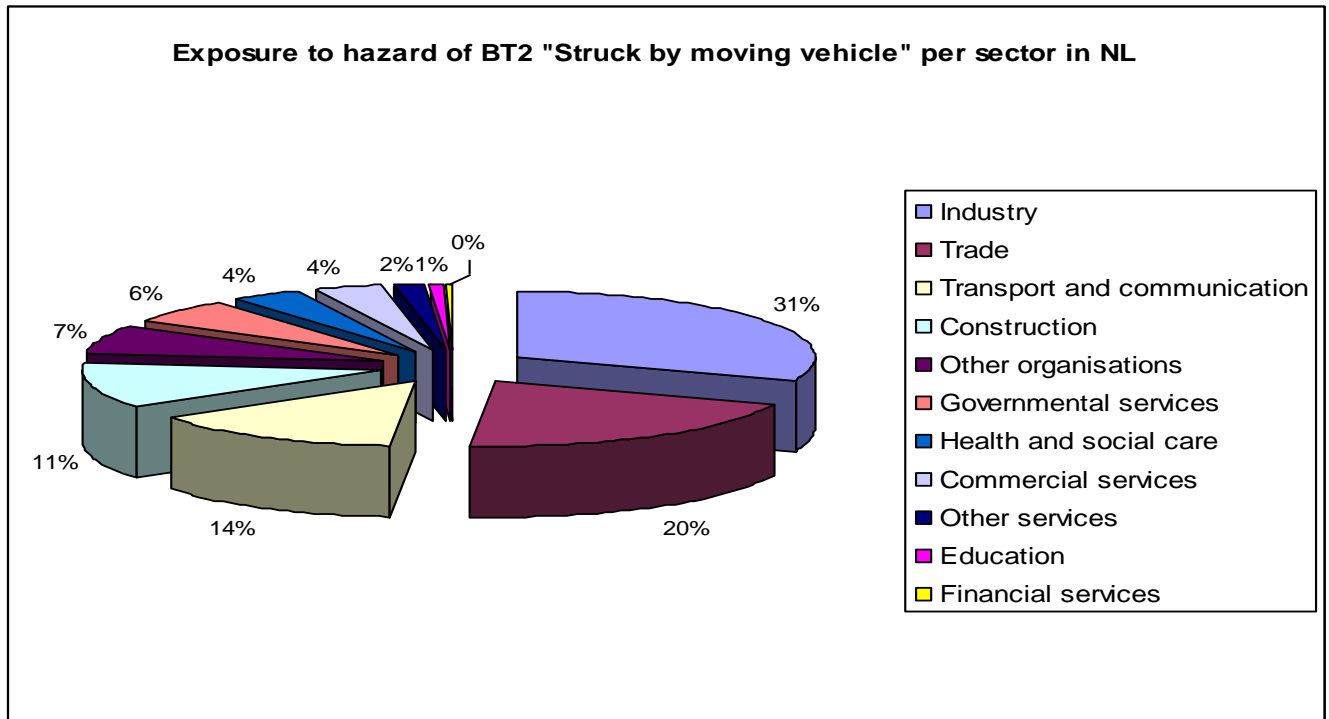


Figure 39 shows the industry division for the employees who are exposed to the hazard “being struck by a moving vehicle”.

3.3 Summary

The Dutch project has contributed with a comprehensive analysis of accidents, their causes and safety barriers, which together with a mapping of the exposure conditions in The Netherlands, have given a basis for being able to calculate the actual risk of accidents with severe consequences in the form of death, permanent invalidity or other severe but recoverable injuries.

The results are given in an overview of 64 hazards, which an analysis of some 9,000 severe accidents have identified.

Identified for these 64 hazards are the safety barriers (PSB, SSB) that for each individual hazard, have failed in the accidents, and there are identified the conditions that determine the safety barrier’s quality (PIEs).

A registration has occurred of in how high a degree the respective safety barriers are:

- Provided

- Used
- Maintained
- Measured

And whether the managerial initiatives have functioned in the form of:

- Procedures/rules
- Equipment/aids
- Design/furnishing
- Accessibility
- Competencies/training
- Communication/knowledge
- Motivation/engagement
- Conflict resolution (process/function)

To be able to calculate the actual risk, a comprehensive survey has been carried out among 30,000 employees in The Netherlands, where the exposure conditions to the 64 hazards and their safety barriers have been mapped.

This also gives valuable knowledge of trade groups and employees in the industries' subjection to the 64 hazards.

The Dutch project has also developed an electronic calculation tool, which makes it possible to calculate the risks for, respectively, death, invalidity and severe injuries, if one states what one does, what hazards one is subjected to and under what conditions this occurs. The calculation system can also tell, which preventive measures can bring down the risk, what it costs, and give an optimisation of which preventive measures can best pay to carry out for a given investment.

Of the results derived from the Dutch project a large number of basic data and statistics are, in the form of exposures divided into industry and trade group.

The Dutch project has been the basis for the Danish project and there has been throughout the entire project period, a close co-operation between the 2 projects.

4. Data collection for the DanWorm project

The name DanWorm is an expression for “Danish Working group for Occupational Risk Model”. The original purpose of the DanWorm project was the following:

- To transfer the Worm results to a Danish version and simplify the program, so that small companies can, in an easy way, form an impression of the actual risk level for accidents in their own company.
- To develop a targeted auditing system, which builds on the accident scenarios that the WORM project has found, and that with limited resources can be used in small businesses.
- To try to establish the quantification of the risk with the safety barriers’ effectiveness on the background of results from inspections based upon data from a limited number of small businesses.
- To draw up auditing forms as a type of self evaluation that makes it possible for a business to establish the effectiveness of own safety barriers.

The goal of having focus on the small businesses is based upon the Dutch project especially having focus on larger businesses, at the same time as the developed software is complicated to use. Therefore, the Danish project views it as a particular task to develop a simplified version, which is less complicated to use.

These objectives were designed at a time where the ORM program was under development. The Dutch progress was delayed especially because of the development of the software and the completion of the “bowtie” analyses. It created a delay of the Danish project, which was dependent upon these results.

However, the work with the Dutch “bowtie” analyses gave a good insight into the Dutch process and results in relation to identifying the safety barriers and PIEs.

Also, from the Dutch side there came a need for making the developed material more accessible and “popular” in the use. This led to significant co-operation across the projects. Especially the use of the many data to create “exposure profiles” of e.g. industry levels are a result of this co-operation.

Finally, part of the methodology work in the Danish project has led to a simplification and adaptation of the Dutch software. The Danish work has, in addition to this, been to make a Danish version and make the software available for Danish users. This is described in section 5.4.

4.1 Tasks of the DanWorm project

In order for companies to use the developed software and form an impression of their actual risk levels, the following are required:

- That one makes a highly detailed account of which tasks are performed and in how long a time converted into a whole year.
- That one makes a highly detailed account of under what safety related condition these tasks are performed.

As the software was in the beginning and the DanWorm project period, it was clear that it required collection and entry of a comprehensive amount of data material for companies who want a calculation of the risk in their own company.

The DanWorm project quickly arrived at the fact that a small company would do this or have it done. The task then became to find a method whereby this could be done for the little company. The result of this is described in section 5.3.

In order to test the developed method and to show its usability a data collection was carried out for 2 industries to see, if one could create a risk profile for jobs in small businesses. The 2-industries/trade groups that were chosen are carpenters and caretakers. The results of the DanWorm project's observations are described below and the risk profiles are shown in section 5.5.

Finally, the observation showed that there is a need, especially in the small companies, for gaining targeted and concrete information about what risks they shall especially be aware of and which safety barriers, in that connection shall be instructed on or paid particular attention to. For this purpose, the DanWorm project has drawn up a number of INFO cards for the most important hazards. The results of the INFO cards are shown in Appendix A.

4.1.1 Data model

The data, which shall be collected is exposure data for work tasks within the 2 industry areas. The type of exposure data is given by the analysed 64 hazards. Thus data shall be collected on all activities and on their relation to the 64 hazards, including data on safety barriers when performing the individual activities. Finally looked at are the managerial conditions that shall support the safety.

In order to be able to register as precisely as the Dutch software system requires, the following structure was drafted for a data collection where

- Job corresponds to either carpenters or Caretakers.
- Task corresponds to e.g. new building or repair work for carpenters and e.g. operation of group heating station or care of outdoor areas for Caretakers.
- Activities correspond to e.g. work on ladders, work on roofs, work with chemicals, etc.
- Safety barriers correspond to e.g. railings on scaffolding or support of the scaffolding.

The data model for collection of the exposure data is illustrated in figure 40.

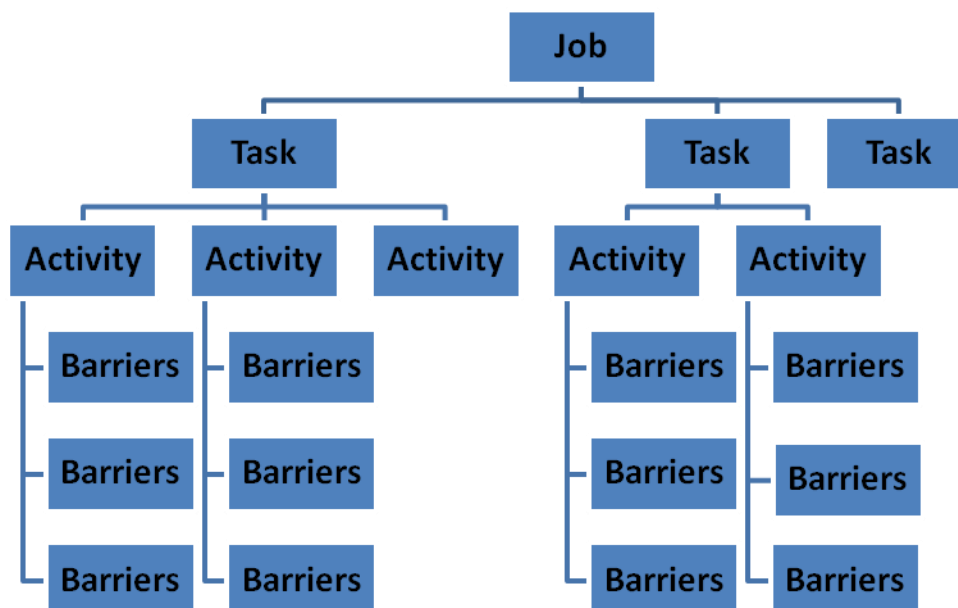


Figure 40 illustrates the data model used for collection of the Danish exposure data.

The model illustrates that the individual jobs are divided upon into a row for the job's characteristic tasks preferably 5-10 items. There shall be talk of tasks with a great difference in content, e.g. for caretaker there can be building repairs, garden work, office work, attending to heating system, etc. For carpenters there can be carcass construction, laying floors, windows and doors, small repairs, purchasing, transport, handling of materials, etc.

The list of the tasks which respectively caretakers and carpenters are divided up in, is shown in diagram 18.

Diagram 18

Carpenters	Caretakers
1. New building, external tasks, such as construction, facades, roof, windows, doors	1. Care and maintenance of outdoor areas (gardener)
2. New building, internal tasks, such as floors, walls, doors, stairs, etc.	2. Building maintenance (bricklayer, joiner, carpenter, plumber, painter) and any cleaning
3. Repairs, renovations, additions, external tasks	3. Operation of heating system (boilerman)
4. Repairs, renovations, additions, internal tasks	4. Ventilation and heating (technician)
5. Demolition	5. Waste management and environmentally hazardous waste (environmental technician)
6. Workshop work	6. Computer/IT (daily administration, maintenance and archiving)
7. Driving, purchasing, waste, transport	7. Maintenance of tools and machines (all-round technician)
8. Administration, customer contact	8. Resident service, resident democracy and practical (guidance, service and support) and guard duty

Diagram 18 shows the division of tasks that are used in data collection for respectively carpenters and caretakers

4.1.2 Data collection method

Fundamentally, the data collection is a time record of the individual activities within the concrete tasks that have been carried out, and a record of any shortages of the necessary safety barriers.

In diagram 19, there is an example shown of the connection between an activity and the respective safety barriers and quality parameters (PIEs).

Diagram 19

Activity and hazard	Primary Safety Barriers	Support Safety Barriers	Evaluation criteria
Work on ladders with the risk of falling	1. Ladder's strength 2. Ladder's stability 3. User's	1. Type of ladder and strength	Ladder's and step's type
			Inspection of the ladder's capacity and length
			Maintenance and storage
			Cleaning

	ability	2. Placement of the ladder and its protection	Placement of the ladder foot
			Placement at the top (ladder angle)
			Protection against traffic that can bump into the ladder
		3. User's ability to work on the ladder	User's position on the ladder
			User's condition
			Use of both hands to hold onto the ladder
			Influence of external forces
			Appropriate movements

Diagram 19 illustrates an example of the connection between an activity and the associated safety barriers and quality parameters, here exemplified by work on a ladder with the risk of fall.

As several activities can be done at the same time e.g. the carpenter both stands on a ladder and works with a hand tool, the data collection is adapted to be able to register up to 3 activities at the same time.

The described details are collected by following a person at work for 3 days and recording the details electronically. In all 20 persons have been followed for the DanWorm project, each for 3 days from morning to night for each of the 2 industry areas. It is sought to cover different types of jobs within the 2 industries small businesses. The 60 observation days per job were used for an average exposure evaluation and a risk profile.

In order to gain details of the individual tasks spread over the year, and the managerial factors, interviews have been carried out with both managers and employees in the business. In these interviews, questions are asked about:

- The practical and safety management conditions for each task
- How often the individual tasks are carried out annually
- To what degree the observed risk actions for the individual tasks are expressions for the general on an annual level
- To what degree the observed safety barriers, their quality and presence are expressions for the general on an annual level.

4.2 Data collection from two sectors

The companies were found via contact with the respective industry safety council, based upon details on Krak and from own contacts. One can discuss the representativeness of the companies that are included in the data collection as there is talk of 5-7 businesses per industry who have been positive in relation to participating in a project about safety, and who are also located in the Copenhagen area with regard to minimising travel.

The collected data can, therefore, draw a too positive image of the safety level without it being studied closer. The process that is followed in the business contact has been the following:

1. The first meeting with the business is a dialogue with management and possibly with employees about the purpose of the study what they can expect to get out of it. It is also agreed here, which of the employees will be followed and when. At the meeting it is also sought to have created an overview of the job's typical tasks over the year in the company,

and when the individual tasks are performed. It is important to have the individual persons followed when they perform the different tasks.

2. In the course of the agreed periods, the selected persons are followed and the details recorded in the electronic data collection.
3. After carrying out the data collection an interview is carried out with management and employees about, partly the managerial details, partly an evaluation of the task frequency and presence of the safety barriers and quality.
4. On the basis of the registered details, a little report is drafted to the company for use by the company's APV. This report is given to the company as a thanks for their help.

In preparation for the data collection, tables were drawn up from the WORM material that could illustrate the industry's most frequently occurring accidents. As the WORM project has integrated Danish data in its system over the occurrence of accidents, the prepared overviews are based upon Danish data from 5 years registration in the Danish Factories Inspectorate. Figures 41 and 42 show, therefore, the 64 hazards for respectively carpenters and caretakers listed out from the frequency of accidents registered in Denmark over 5 years.

Figure 41

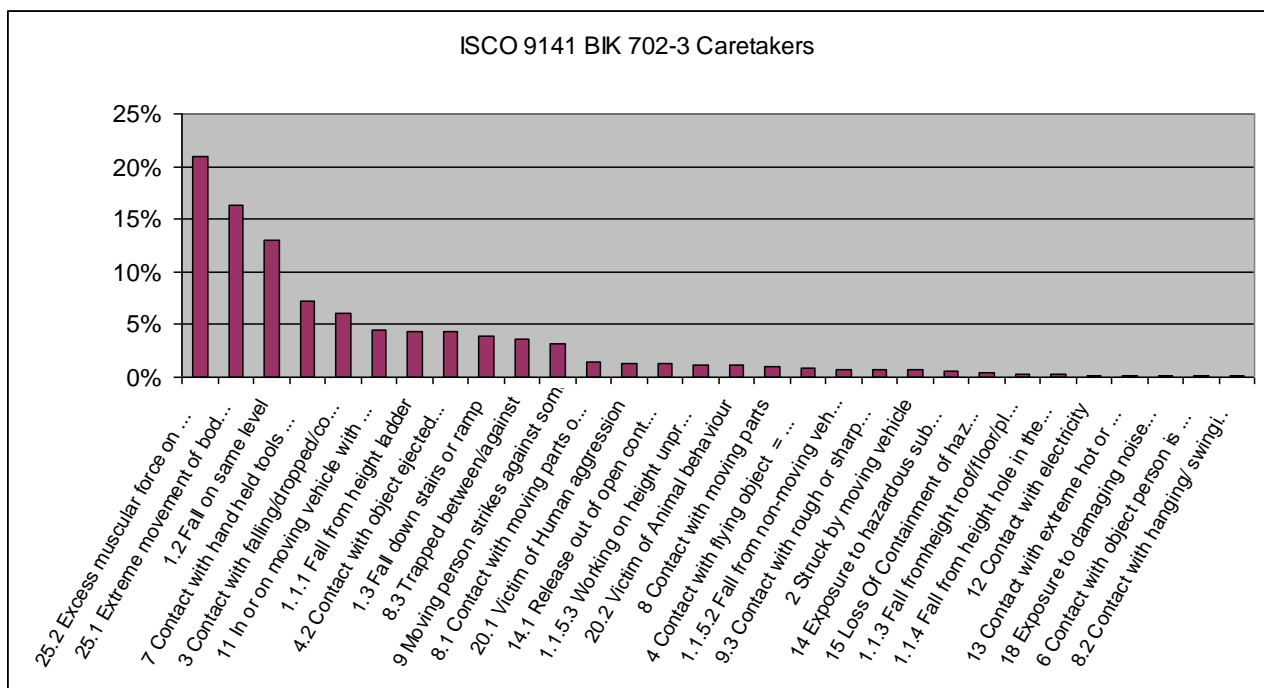


Figure 41 shows the frequency of accidents for caretakers in Denmark over a 5-year period.

Figure 42

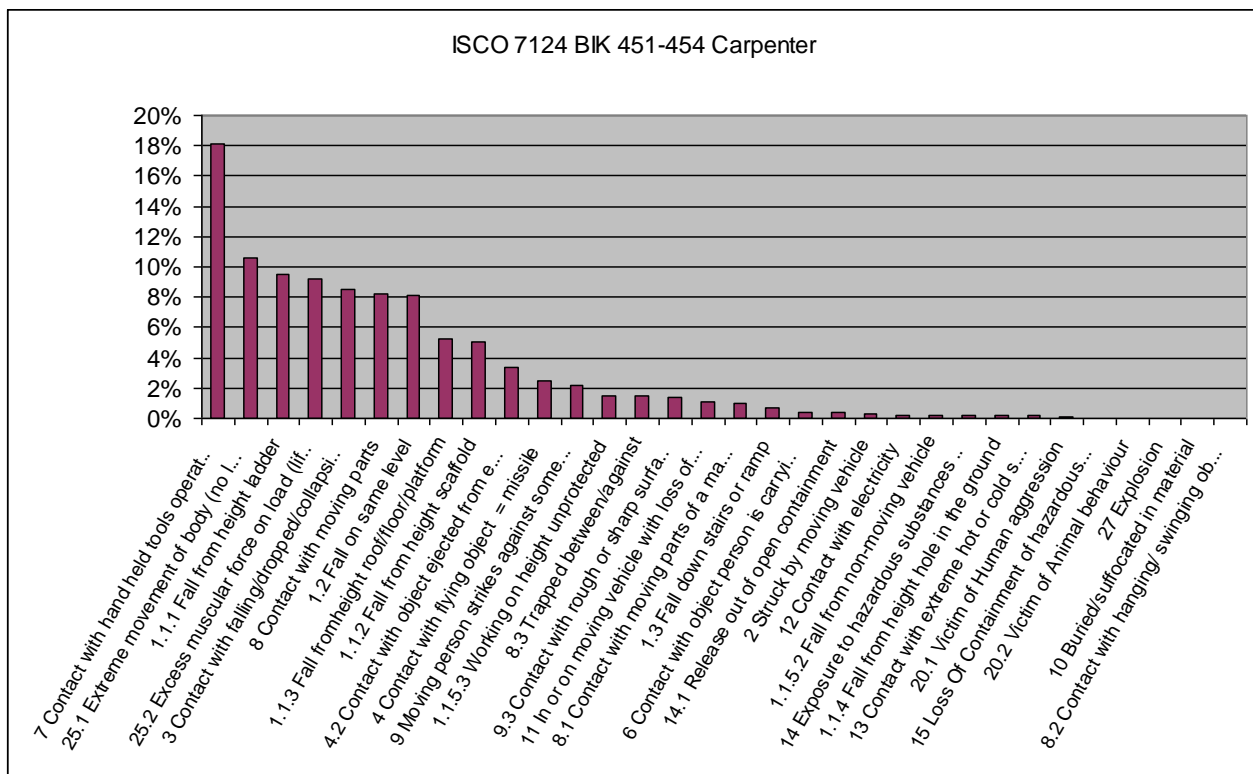


Figure 42 shows the frequency of accidents for carpenters in Denmark in a 5 year period.

4.2.1 Carpentry and its risks

Data collection was performed at a total of 5 carpentry companies all placed within the Greater Copenhagen area but divided by both city and country. The company's size varied from 3 employees to 40 employees. Here follows a description of the risks and hazards, which were observed in the companies.

Working at heights

As expected, much work was carried out at heights, that is to say, on ladders and scaffolding and common to the 5 companies is that they have a good consciousness and attention to ladders and scaffolding being in order. Generally they work in a calm and attentive manner in relation to clear risks of falls, which compensates for work on e.g. ladders often is carried out with both hands i.e. without one holding onto the ladder. Often brought along are rolling scaffolding and ladders that can ensure a good working height. Yet, sometimes compromises are made which coincides with the nature of the task and the great degree of flexibility and ad hoc character. This applies, among others, to the scope of railings and securing of ladders.

Work and activities in level

Work and activities are carried out in levels at many different types of areas, where there can be demolished building materials, earthwork, new building materials, lines, etc. This is difficult to change, as the company isn't solely responsible for the site, but to a great extent depends just as much on customers, other trade groups and the nature of the task. There is attention to clearing up, yet work is often carried out in areas where there are materials and cabling that does not necessarily need to lie where one walks. Often during renovations, digs can occur in the area. Here, it should be thought over where carpenters and others walk most so the access roads in the least are even, without holes or obstacles. There is a general need in the industry for a more consequent clearing up

of work areas, so one can walk unhindered. Observations were not carried out during the winter period, but experience shows snow and ice can be a problem. Securing of access conditions and outdoor workplaces in the winter should occur with regard to this.

Surroundings

The surroundings can contain risks, like bumping into things, being struck by something and getting something down over oneself, falling objects, slipping of materials, etc. For demolition tasks it is important to have focus on the materials one takes down, for example, old glass wool or other and whether one can get it in the eyes. In such a case dust masks and gloves should always be used.

It varies greatly whether employees are alone or together while working. If one works together two and two it most often means that one goes round each other on the same site where materials, planks, etc. are handled. Thus there is a risk of one bumping into each other or one can hit each other while handling materials. On the other side it also gives the opportunity for one to help each other and e.g. be 2 during heavier lifting. When materials are delivered one must be aware of situations where the materials are lifted into place by a crane or similar. One must either keep at a distance or, if necessary, be close by and protect oneself e.g. with a helmet.

Again the employees' calmness, overview and mutual consideration for each other plays a great role to safety. The general impression is that there is a great mutual consideration and mutual helpfulness between craftsmen in the small companies.

Hand tools

Hand tools are predominantly used – both manual and mechanical. A constant interaction occurs in the use of the most common tools that are associated with the carpenter trade. They are generally handled very professionally. A comprehensive part of the work, is carried out using hand tools on a ladder or scaffolding, where one necessarily must use both hands to work. Balance and good physical condition are, therefore, a necessity. Similarly that there are good tools and that ladders and scaffoldings are in order and have a proper foot support. These things are, for the most part, in order in the companies. Both in the form of maintenance from the company's side and employees own attention to things needing to be in order. However, it is an behaviour to lay hand tools where one walks and stands because one will use them again in a little while. There is e.g. observed, that tools at times are placed on rafters or collar beams, where people walk below. There is a need for more fixed procedures, where tools are placed during work, in the periods where they are not in use. E.g. in a bucket or on a rack.

Use of vehicles

Employees normally have a car at their disposal, because they drive from task to task and to collect materials. Therefore, there is a certain risk of accidents in traffic. There is also talk of the use of handheld mobile telephones while driving, even if some have handsfree sets at their disposal, they are not used. There shall therefore, possibly, be thought about telephones that have a better and simpler potential for use while driving. Beyond the risk of driving the wrong way, one also breaches the Road Traffic Act.

Cars are used both for normal transport and for the storage of tools, working machines, etc. Therefore order and maintenance of the tool storage area and transport in the cars is a task. The cars and the tools are gone through and maintained every half year. The master keeps an eye on employees who are "known" for loading too much or having a mess in their car.

Machines

Work is primarily done using smaller machines, which can be carried from place to place. Some of these machines have legs mounted, so they can be used at a normal working height, while others are used, where it is now possible, either at an accessibility table or on the ground/floor. There is talk of saws, crosscut machines, etc. They are generally equipped with the necessary safety equipment, however sometimes lack a cover or a gap knife. Carpenters sometimes also use machines at the workshop itself and individual machines are observed without the correct safety equipment. It is recommended that all stationary machines are gone over and equipped with the necessary equipment and that maintenance, cleaning and inspection of the technical equipment is an important safety task.

Electricity

Electrical tools are worked with. Therefore, there is often cabling up to the workstation. Here, there is, however, more a question of the cabling giving a risk of fall before a risk of electric contact. That is to say, there is a need for securing good cabling, where work is carried out. There are also tasks such as e.g. demolition, where there can be defective cabling. In such cases an electrician is called to handle the task.

Heat, Cold

Sometimes work involving asphalt paper and heat of the roof, where there can be a risk of fire and combustion. Again, being careful, calm and maintaining an overview are necessities.

Chemistry

Immediately, there is only in a small scale work with hazardous chemicals and there was observed a general attitude toward using water-based solutions. However, there are cases where lime etc. is used, which is hazard marked. It is therefore recommended that some simple instructions are made for safety requirements for use of these materials, which can be given out together with the materials. The requirements are stated in the usage instructions and can be retrieved from the following website www.styrpaastofferne.dk

It is also observed that wood protector and paint were used without labelling on the container. Also that one investigates the content in the unmarked containers by smelling them. It is recommended that all chemicals are stored in correctly marked containers specified with a code number, and that there is a simple brief usage instruction of the chemicals that are marked with code numbers 2 and 3.

Loads

A number of building materials and tools are lifted and handled. This normally occurs over shorter periods of time. In cases of larger tasks there are more people working on the task. The combination with heavy loads and cold is, however, something that one must be aware of.

For larger deliveries of building materials the supplier drives the materials out with the possibility that the materials can be lifted into place, so further lifting is reduced. When working on scaffolding one is generally aware and lifts materials up with a bucket and line. There could be the need for having a simple aid that can be mounted on the scaffolding that can contribute in the lifting of materials up and down.

Building materials are predominantly of wood and plaster, but a number are also of glass or metal which mean there is a possibility of cutting oneself. Generally, there are always gloves available but there is a slight difference as to whether they are used.

Renovation of doors and windows hold a particular risk for broken panes. There should be a clear instruction as to how these tasks shall be performed.

Due to the large number of lifting and handling of materials, both light and heavy, in many different situations and surroundings, it may be appropriate for all to be trained in correct lifting techniques. Also, a good physical condition is essential.

Other accident risks

Other risks include fire, explosion, drowning, suffocation, etc. These are not risks that are not normally included in the tasks that are carried out by the carpentry company. There can, however, be tasks where there is the need for particular attention, such as if work is carried out near areas with water or where there are other trade groups in the area, where such risks are included.

Due to the nature of the tasks, which are to repair damage to buildings of very different characters, there can be situations where lines with electricity, gas, etc. are damaged. It is important that carpenters are instructed carefully about how they can observe such risks and how they should act in such cases.

Other health risks

Electrical tools are worked with frequently. Especially saws and drills are noisy. Hammer drills not least. Hearing protectors are always available and it is recommended that they are used.

Renovation tasks can also involve the presence of dust, for which there should be protection against. Dust masks are generally available with the recommendation that they are used in the necessary scope for particularly dusty work, but it is up to the individual carpenter to put them into use.

4.2.2 Risks and hazards to caretakers

A caretaker has the task of taking care of the daily running of a property company's property. The caretaker is associated with a property office with from 1 to approx. 20 employees.

The individual property office can contain all of the employees in the relevant property company, but the property company can also own or administer a number of properties, and thus comprise a number of property offices attached to a central management. Finally, the caretakers at the relevant property office can be employed by the property company but be managed by a different company who, at the same time, is responsible for the administrative operation of the property. However, it is often so that the individual property office is quite self-governing.

A data collection has been performed at a total of 7 properties, all located within the greater Copenhagen area, but divided both within Copenhagen itself, as in the outer areas.

Work at heights and on a level

In the caretakers work, a large part of the time is spent in outdoor areas, roads, paths, pavements and grass, as well as indoors in cellarways and up and down stairs. When driving tractors he must get in and out of the tractor. The other caretakers can stand on the vehicle while driving and shall also climb up and down, finally the loading and unloading of trailers means that one goes up and down off the trailer. Due to this there is the risk of injury from falling on a level, falling from trailer and tractor and falling on stairs. The work is carried out at a slow pace.

Caretakers seldom work at heights but the use of ladders (normally under 2 metres) occurs often, among others, when replacing light bulbs in staircases and when repairing gutters (plumbing and heating man), cutting of trees from ladders can also occur. In special cases, however, they may work on roofs of help workmen who e.g. repair a roof.

Transport

Transport with motor vehicles, among others, for collection of bulky refuse and for lawn mowing occurs both on even roads, over kerbstones and on uneven grassy areas. Driving primarily occurs in areas with no traffic (opposing traffic) or very limited traffic. Transport in motor vehicles can give the risk of hitting something in the driver cabin in the event of a bump, with overturning, or if something is driven into, or into other motorists. Under transport, the other caretakers can sit or stand on the vehicle. They can, in a similar manner, injure themselves by falling and by driving into the tractor's parts.

Loads

During the work quite a bit of rubbish and bulky rubbish is lifted up and down cellar stairs and up and down from trailers and into containers, among these, old tables to gas jets and white goods. Handling of waste containers and the use of some of the machines that are pushed or pulled around can have the character of heavy work, among others, the use of leaf vacuums. This gives a great deal of lifting and pushing work, where part is heavy work that causes the risk of injuries to the back, arms and shoulders.

With plumbing and sanitation work there is the risk of injuries in the form of twisting etc. from poor working positions when repairing taps and rinsing drains, etc. There is the risk of bumping the head, hands and other body parts against the walls and other objects because it is difficult to reach.

Hand tools and machines

Hand tools such as a sack truck, Stanley knife and a "tricker" for rubbish; broom, shovel and wheelbarrow when sweeping and weeding hoe when weeding; lopping shears and saw when cutting. This gives the risk of injuries such as pricking, clipping and cutting oneself on a knife.

Machines are used for waste handling such as tractors and tractors with lifting equipment to empty containers, tractors with cranes, motor saws for cutting, "whisks" for removal of weeds, grass clippers (hand truck, little tractor for grass clipping and large tractor), equipment for chipping of bush/ tree remnants, stub miller for removal of stubs, band saw. Machines are filled with fuel, etc., connected together, handled, and repaired also by the caretakers. Work with the machines gives, therefore, the risk of severe cutting injuries on e.g. arms and legs, if one comes near the cutting parts. There is also the risk of injuries such as squeezing, poking, clipping and cutting when handling and repairing machines. Generally used are the required personal safeguards when using the machines.

Surroundings

Work outdoors for many hours during summer and winter gives the risk of heat/cold effects, which can lead to an increased risk of infectious diseases. Work collecting and handling waste and handling waste from dirt and plants, among others, leaves can involve subjection to hazardous microorganisms with the increased risk of infectious disease as a result. Work with waste can involve subjection to hazardous microorganisms with the increased risk of infectious disease as a result.

Part of the sweeping occurs out on a closed road with a certain amount of traffic. There is therefore a certain risk of being injured by being driven into.

The work outdoors can also involve the risk of getting something on one's head – when handling waste from waste, which galls down when, among others, emptying containers and from branches when cutting bushes and trees.

A number of the machines give the risk of being struck by thrown out parts when working and "hitting stones or the ground". This gives the risk of being hit on the body and in the eyes, both by

the person who operates the machine and, in part, colleagues close by or persons who pass the work place.

Corrosion and fire/explosion etc. can occur when handling chemicals. Chemicals are handled only in a very limited scope, among others, when filling petrol/fuel for use in machines, when filling cleaning agents in the laundry rooms and during cleaning and repair work. Cleaning staff are most subjected, but also plumbing and sanitation tasks can mean the use of cleaning agents, solvents, etc.

Risk of Burning

Burners are used for the removal of weeds, which gives the risk of burns.

Electricity

Power tools are found in a very limited scope, among others, in the form of drills (battery) and coffee makers. There is an agreement for an annual check of power tools. One task is also replacing defective light bulbs and light tubes in cellars. It looks as though light bulbs and light tubes occurs while there still is current. This gives the risk of contact with the live parts and thus for electric shock.

Human aggression

The caretaker can be subjected to human aggression from residents and others when the person enters into confrontations, e.g. when rules shall be stressed or when disagreements occur e.g. when inspecting flats during moves in or out. This can lead to physical or mental overload.

4.3 Recommendations to the companies

It became very clear during the observations that the employees' independence in the work is distinct and that they, in the least in these two industries, work away from the home company, i.e. outside of the employer's possibility to follow along with, instruct in or inspect the work. It is also clear that the tasks are very varied often from day to day and shall be carried out under terms, which the employer or employee does not have the full influence on. These two significant conditions for management work and for safety work have set their stamp on the recommendations, which are given to the companies and to the recommendations that this report leads to.

4.3.1 Carpenter companies

The experience from the carpenter companies is the following:

1. The employer in the small company will generally usually create good safety conditions for his employees, but he does not have the large resources to search for knowledge or methods. This knowledge shall be easily accessible and targeted.
2. The employer in the small company shall perform the daily administration and job allocation, agreements with customers, procurement of materials, etc. In this course one goes in between compromise with the rules, partly to get jobs in house and partly in order to get logistics to run. Methods and materials are used, when they are easiest to use and where there is a general understanding of one only does this when one is a professional.
3. Most carpenters' assistants work independently with responsibility for an apprentice or junior assistant. He often orders his own materials and he must ensure that his car and tools are in order.
4. In many tasks, the carpenter's assistant is the only person who has the possibility to evaluate working conditions and evaluate the risks that are on site.

5. It is the general perception of what is dangerous, which will apply, i.e. what is taught, what is the rule for, or what is informed of by organisations.

Based upon this, the recommendations for the small carpenter businesses are divided up into two parts, namely a plan for the employee and one for the carpenter's assistant who has the responsibility for a concrete task.

10- point plan for the employer

Employers in the small carpentry business were given a 10-point plan, which includes the following:

1. Plan for safety and daily attention

The goal for safety and health in your company can be:

"that it is strived for to as high a degree as possible for all tasks to be performed under consideration for the employee's safety. This applies both to where one walks, stands on a ladder, scaffolding and roofs, as what one works with".

As the tasks are highly varied and change from day to day at highly different workplaces, there will always be the need for evaluating safety in the task from place to place and from job to job.

One way of doing this, without it becoming all too troublesome, is for the carpenter's assistants to think through the 10 points for safety evaluation before a job begins. This requires, however, that the employer has given instruction and training herein, so that the carpenters can do it by heart. In the beginning it may also require there being joint morning meetings. When first the carpenters know the 10 points by heart, no greater initiative is required than that, which is to perform the tasks in a safe manner.

2. Focus on safety in all directions

Safety is increased by increased focus – and this shall apply in all directions. This means that out in the individual site there shall be focus on the daily safety. All employees shall know the safe way of working and there shall be focus on safety equipment being used at work.

If the clerk of works does not have the possibility for keeping focus on safety onsite, because he drives around one, each site shall be designated to ensure that there is focus on safety, that morning meetings are held with safety on the programme, and that it is cleaned up regularly.

3. Cleaning up on work areas and scaffoldings

A fixed procedure for cleaning up of those locations are where work is performed and gone about during the work, so that one doesn't always have to look where one sets one's feet, when the focus is on the task. E.g. that cleaning up is not only done at closing time but also before lunch.

4. Laying cables in work areas

There should be a set procedure for laying cables in the work area. Cables should, as far as possible, be laid where one is not walking or in the best case be hung up.

5. Placement of hand tools during use

There should be a fixed procedure for the placement of hand tools, when they are not immediately in use, but will be used with a short space between. The tool can, e.g. be placed in a bucket.

6. Accessibility of equipment, safety related aids in cars

A fixed procedure for tidying up is the care and ensuring that the necessary safety equipment is always available. Equipment is e.g. gloves, dust masks, hearing protection, tape, first aid box, etc. Clerks of works shall be aware as to whether the equipment is used.

7. Maintenance of tools

Maintenance and cleaning of all tools and machines is important. Look after everyone by taking defective tools back for repairs and not using them.

8. Use of machines, procedures and safety equipment

Ensure that machines have the necessary safety equipment. A good practice shall also be created when working with machines without this equipment – a sound respect and working form.

9. Correct lifting techniques

One fixed procedure for all forms of lifting. A potential collective training session in correct lifting techniques is given by a physiotherapist one Friday afternoon. Also, a membership to a fitness centre can be given out.

10. Use of mobile telephones while driving

Installation of holders for mobile telephones in all cars and equipment so that one can speak on the phone without using one's hands.

10 points for carpenter's assistants

As a supplement to the plan for the employer, 10 points were given to the carpenter's assistants that they can have e.g. in their car, and that can be a form of reminder they can use to evaluate the risk in a given job and for assessment of which measures they should take before commencing the job. The 10 points include the following:

<p><u>1. Safety on scaffolding</u></p> <p>Check railings, foundations, access, tidiness, distance between scaffolding and wall, close the access hole during work, well-being</p>
<p><u>2. Safety when working on ladders</u></p> <p>Check maintenance, stability, ladder strength, ladder length, protection against skidding</p>
<p><u>3. Safety while working at heights, on roofs and similar</u></p> <p>Check shielding, cage-arresting device, well-being</p>
<p><u>4. Tools and machines</u></p> <p>Check maintenance, safety equipment, storage, cabling</p>
<p><u>5. Protective equipment</u></p> <p>Check that the necessary equipment is always available, that it is replenished, that you can offer first aid</p>
<p><u>6. Lifting of loads and working height</u></p> <p>Check that you are two for heavy lifting, that there are aids, e.g. for up and down hoisting of scaffolding, correct lifting technique, use of work platforms, stepladder, etc</p>
<p><u>7. Work and traffic area</u></p> <p>Check cleanliness, cleaning, lighting, cabling, gravelling when there is ice/snow unevenness</p>
<p><u>8. Waste management</u></p> <p>Check waste management in working areas, storage, removal, use of gloves</p>
<p><u>9. Transport</u></p> <p>Check driving behaviour, and the car's maintenance and cleanliness</p>
<p><u>10. Consciousness of risks in tasks that include:</u></p> <ul style="list-style-type: none"> • Sharp objects • Pricking objects • Squeezing • Bumping into • Risk of fire

- Chemical risk
- Dust
- Explosion
- Slipping
- Falling objects
- Slippery, uneven surfaces
- The potential for falling
- Other motorists

4.3.2 Caretakers

In the following there are given a number of recommendations, which have come to light based upon the observations carried out.

1. Attention to hazards

Caretakers generally feel that their risk of being subjected to workplace accidents is small and the consequences of any such accidents are limited. This is because they have not experienced any or few accidents at work and they feel that the relevant accidents are self-caused. It is therefore important to find methods of making the hazards for workplace accidents visible and relevant.

2. Self-management

Caretakers generally have a great influence on organizing their own work, which generally is performed in areas a bit away from the property office and without management directly monitoring the work. This means that the individual caretaker or group of caretakers, to a great extent, must take care of their own safety/the group's safety. The individual employee shall, therefore, be in a position to evaluate their own and the group's danger and need for safety measures. Management must be clear in its role to secure that the individual employee can perform his tasks safely, to secure that machines, etc. are in order and to provide safety equipment. Management must also clearly state their expectations in the safety area and in a sufficient degree monitor the work, advise and step in if the work is not performed in a satisfactory manner.

3. Unskilled employees

As employees are, as a starting point, unskilled in relation to the work as caretakers it would be a good idea if the employees were trained so that they, in the best possible manner, can attend to safety when working with the dangerous machines (e.g. motor saw), they handle and in working positions and with good lifting techniques in the highly manual work that they have. Finally, they should also be trained in work with waste including sorting. Courses are offered in this field.

4. Highly manual work

Work that the caretakers perform is to a high degree manual tasks that occur outdoors. Even though there is a lot of heavy work and quite a bit of one-sided repetitive work it does not seem to be very strenuous, perhaps with the exception of handling hard white goods and bulky rubbish. One can therefore dream about the caretaker's job as being, sound work, and strive after tasks that collectively give a sound body.

Caretakers could, due to the risk of long-term exposure, regularly receive instruction in and checks of their positions. It may also be an idea to ensure that employees' physique is kept in good form e.g. but supporting access to a fitness centre/gym. In order to ensure a sound body this could be supplemented with a better awareness of healthy eating habits. As it seems many caretakers eat wrong and too little.

Finally, there should be a prevention of injuries from outdoor work e.g. in the form of use of cream against sunburn and sunglasses against sharp light and the use of head coverings such as a sunhat/cap.

5. Furnishing of workshops

Many of the caretakers are trained workmen, who therefore have the professional background to carry out a number of repair and maintenance work. But as this is not the caretaker's primary task, there is a tendency of equipment and interiors not in all cases corresponding to a professional standard. This especially applies to the furnishing of workshops.

Management should therefore, in relation to repair and maintenance work, make agreements as to which tasks can be performed and then ensure that furnishing the workplace, tools and machines, equipment and personal protective devices are in order in relation to the tasks.

6. Plumbing and sanitation work and waste management/washing

Work with plumbing and sanitation work and shafting results in many poor positions, this is due to the furnishing of facilities for waste management, furnishing of the kitchen and bathrooms, and furnishing of laundry rooms have not, in a sufficient scope, had regard paid to safeguarding repair and maintenance work. Property companies stand for building and furnishing of flats and joint facilities. Therefore they have a very good potential for creating better working conditions for caretakers.

7-point plan for the employer

1. Training

Ensure that employees have sufficient knowledge about carrying out their jobs safely.

Possibly ensure employees are trained particularly within

- work with hazardous machines among others motor saw
- ergonomics – good working positions and lifting techniques
- work with sorting waste

2. User ability – much manual work

Motivate employees to a sound way of living/promote health Provide access to a gym, healthy food and possibly massage.

3. Furnishing of workshops:

- Evaluate which tasks you want your employees to perform.
- Furnish workshops professionally in relation to this, among others, with good working tables, sufficient ventilation and point extraction, in heated, tidy workshop locales with sufficient ceiling height.
- Instruct employees in which tasks they can perform themselves.
- Instruct employees as to which tasks shall be performed by external workmen.
- Instruct employees about what you want them to do if the workshop and machines are defective.

4. Furnishing of workplaces:

- Observe and evaluate work processes, access and space for the tasks the employees perform especially for waste management including shafting, with cleaning and repairs of laundry machines and with plumbing and sanitation work.
- Ensure that the workplaces are furnished appropriately in relation to the tasks.
- Instruct employees in safe performance of the work.

5. Equipment and behaviour in order:

- Motivate and instruct employees about how you want their behaviour to be so that work is performed safely and they avoid accidents.
- Ensure that hand tools, ladders and machines are available and in order.
- Ensure that the necessary personal protective devices are available and in order

- Ensure for cleaning, repairs and maintenance of technical aids, personal safety aids and working areas.

6. User ability – much manual work

Observe and evaluate whether the employee:

- is in a position to carry out his tasks safely,
- has the ability and knowledge about safe use of the tools and machines he shall use,
- is in good condition in relation to the work he shall perform,
- is aware in relation to hazards and has good safety related behaviour.

7. Ensure for

- clear instructions/agreements
- good division of responsibility and tasks
- positive motivation to safe behaviour
- to state how you want them to act if they observe faults and deficiencies
- a consequent attitude for violations

6 points for caretakers

1. Training

Participate in the necessary courses for your job, among others, courses in

- work with hazardous machines, among others, motor saw
- ergonomics – good working positions and lifting techniques
- work with sorting waste

2. User ability – much manual work

Be aware that the highly manual labour demands a healthy body. Participate in activities about a healthy way of living/ promoting health. Use the opportunity for access to a gym, healthy food and possibly massage.

3. Furnishing of workshops

- Follow instructions on which tasks that must be performed by you and your colleagues
- Use the furnished workshops including point extraction and personal safety aids
- Report faults and defects to the manager

4. Furnishing of workplaces

- Follow instructions on the safe performance of the work
- Report faults and defects to the manager

5. Safe behaviour

- Observe and evaluate whether hand tools, ladders and machines are available and in order.
- Observe and evaluate whether the necessary personal protective devices are available and in order
- Follow instructions for safe use of equipment
- Ensure there is good safety related behaviour during work and good order and cleanliness during and after

6. User ability

- Follow agreements and instructions
- Evaluate whether you are in a position to carry out your tasks safely,
- Evaluate whether you have the ability and knowledge about safe use of the tools and machines

you shall use,

- Evaluate whether you are in good condition in relation to the work you shall perform,
- Be aware in relation to the hazards your job tasks involve.
- Report faults and defects to the manager

4.4 Summary

In that connection, a little electronic registration tool was developed, which gave an observer the possibility to collect and time register tasks, activities and safety barriers, for the person who performed the work.

This tool has functioned very satisfactorily and absolutely fulfilled its purpose. By following persons and recording their activities, very precise details are obtained and many specific details that otherwise would be difficult to ask about or be informed of in a different way.

However, the method is time consuming and requires a comprehensive data collection in order to be able to create a representative foundation. The time consuming element shall, therefore, be weighed up against the use of a questionnaire, if one wishes to repeat a mapping of the concrete exposure conditions in an industry or in a company.

On the other hand, following a number of persons so closely over 3 days has given good insight into both the daily tasks and the problems that the individual employees come out to solve, and at the same time gives an insight into the culture the individual uses as the basis for his work. This knowledge has subsequently given inspiration to both feedback to the company and what should be included in their APV.

Insight into the small company's way of working and the conditions it functions under has given the background for evaluating what one can anticipate and what one can instruct the employer in the small company to do for safety in the company. But also what one can and should expect from the individual employee in relation to himself being able to perform an ongoing evaluation of his own risk.

However, such a division of responsibility and duty places a clear demand that the employee is instructed and guided and that there has created an opportunity for the employee knowing how he shall risk assess, and that the employee has the materials, tools and time available to create safety in the task. Finally, it is essential that the employer motivates the employees to risk assess tasks and act safely.

5. DanWorm project's results

The project results are presented in 4 parts:

1. Comprises a systematic access to the Dutch hazards and methods for making this information usable to smaller businesses.
2. Comprises the work with a Danish version of the Dutch data, and assistance in developing and simplifying the software for the risk calculation through a "light" Danish version of the calculation program Orca (Occupational Risk Calculator Assessment).
3. Comprises a method of collecting the data, which is necessary for the risk calculation in ORCA.
4. Comprises the results of the data collection for 2 trade groups, carpenters and caretakers, including the 2 trade group's risk profiles.

5.1 Hazards, safety barriers and INFO card

5.1.1 Hazards and risk situations

In the Dutch WORM project 64 hazards in total were identified, cf. Diagram 11. Each of these hazards can be connected with an activity or a situation where there is a risk for a certain accident event, e.g. "activities in areas where there is moving traffic" involves a risk of "being struck by a moving vehicle".

The DanWorm project has sought to make it easier to work with the 64 hazards and the associated risk situations. This is done through a 3-divided grouping of the hazards in respectively:

4-17-64

The 4 risk situations, which make up the first stage of hazards grouping is characterised by the following:

- A. The foundation where it is walked or worked on, with the risk of fall;
- B. The surroundings that are walked on or worked in with the risk of bumping into something, being struck by something, getting something over oneself, etc.
- C. What is worked with or by, with the risk of being squeezed, poked, cut, etc;
- D. Surroundings of a particularly hazardous character, with the risk of explosion, fire, etc.

The 17 risk situations, which make up the second stage of hazards grouping are the following:

A	1. Working at height
---	----------------------

	2. Working at the same level
B	3. Working where objects can fall 4. Working where objects can fly around 5. Work where you can be struck by objects, collide with something or be squeezed 6. Work where you can become buried 7. Work with people and/or animals
C	8. Machines and tools 9. Vehicles 10. Electricity 11. Heat and/or cold 12. Chemicals 13. Heavy lifting
D	14. High voltage 15. Fire hazard 16. Suffocation/choking 17. Explosions

The connection between this 4-17-64 grouping is shown in the following overview diagram, diagram 21.

Diagram 21

<i>Characteristics</i>	<i>Activity</i>	<i>Risk</i>	<i>Hazards</i>
A. The surface which is walked on or worked at;	1. Work at height	Fall from height	1. Fall from height – movable ladder
			2. Fall from height – fixed ladder
			3. Fall from height – step ladder
			4. Fall from height – rope ladder
			5. Fall from height – mobile scaffolding
			6. Fall from height – fixed scaffolding
			7. Fall from height – putting up/taking down scaffolding
			8. Fall from height – roof
			9. Fall from height – areas, floor with large level difference
			10. Fall from height – fixed platform
			11. Fall from height down in hole (e.g. in earth, floor)
			12. Fall from height – mobile platform
			13. Fall from height – holding vehicle
			14. Fall from height – work at heights without protection
B. The surroundings	2. Work at a level	Fall in the same level	15. Risk for tripping up or slipping on the same level
			16. Fall from stairs or slanted surfaces
	3. Falling object	Struck by falling object	17. Struck by falling object – crane or lift
			18. Struck by falling object – mechanical lift (excl. crane)
			19. Struck by falling object – from vehicle or conveyor

Characteristics	Activity	Risk	Hazards
which is walked on or worked at;	4. Frag-objects	Being struck by frag-objects	20. Struck by falling object – from manual lift
			21. Struck by falling object – other objects at height
			22. Struck by falling object – from machines or hand tools
			23. Being struck by fragments – from objects under pressure/stress
	5. Colliding against, in between, being struck by	Being struck by moving objects, squeezing, being mast.	24. Being struck by fragments – that are blown by the wind
			25. Collision with vehicle
			26. Being struck by rolling/sliding objects
			27. Being struck by hand tools held by another person
			28. Being struck by hand tools held by another person
			29. Being struck by swinging objects
			30. Becoming caught/jammed between objects
			31. Colliding against/with objects
	6. Sliding of materials	Being buried	32. Buried under loos material
	7. Aggression	Violence	
			33. Exposure to aggressive people (violence)
			34. Exposure to the behaviour of animals (falls, bites, stings, kicks)
C. What is worked on or with;	8. Technical aids	Being struck by moving objects, becoming caught up/jammed, cutting	35. Being struck by own hand tools
			36. Being struck by moving parts of machinery - operating
			37. Being struck by moving parts of machinery - maintenance
			38. Being struck by moving parts of machinery - preparing
			39. Being struck by moving parts of machinery - cleaning
	9. Vehicles	Collisions	40. Loss of control over vehicle
	10. Electricity	Electric shock	41. Contact with electricity – electrical equipment
			42. Contact with electricity – when installing/repairing
	11. Heat or cold	Burning	43. Burning - freezing/burning with cold/warm surfaces or open fire
			44. Fires – combustion from “hot” work
	12. Chemical	Poisoning, etching	45. Discharge of dangerous chemicals from open containers
			46. Contact with uncovered hazardous chemicals (without discharge)
			47. Release of chemical risk from closed containers - work/filling/draining
			48. Release of chemical risk from closed containers - without
	13. Lifting, heavy loads	Strain injuries	49. Release of chemical risk from closed containers – when closing
			51. Extreme exertions – heavy lifting
			52. Extreme exertions – inappropriate movements
D. Surroundings of a particularly hazardous nature.	14. High voltage	Electric shock	53. Contact with electricity – high voltage cables
	15. Fire	Fire	
			54. Fire – flammable and easily combustible substances
	16. Lack of oxygen and water	Suffocation, poisoning or drowning	55. Fire – fire extinguishing
			56. Suffocation/poisoning – work in confined spaces
			57. Suffocation/poisoning – work with respirators
			58. Drowning – work in/under the water or liquids
			59. Drowning – work above/in the proximity of water
	17. Explosion	Explosion	60. Physical explosion
			61. Chemical explosion – vapour or gas
			62. Chemical explosion - dust

<i>Characteristics</i>	<i>Activity</i>	<i>Risk</i>	<i>Hazards</i>
			63. Chemical explosion - explosives
			64. Chemical explosion – exothermic reaction

Diagram 21 shows the connection between the 4-17-64 division, between activities and hazards.

A person can very well be subjected to multiple hazards at the same time, e.g. when working with hand tools (35) while on a roof (8), where there is also the possibility of things one works with falling down (17) e.g. in an area where other persons are walking at the same time (15) as they carry heavy loads (51)

This structuring offers a method for evaluating risks on concrete workplaces, such as e.g. when carrying out a workplace evaluation.

The intention is that one starts by focusing on one of the 4 primary risk situations that are covered by step 1 and asking the following questions:

- *How are your legs – What kind of foundation do you stand, work or walk on?*
- *What are your surroundings like – What hazards do your surroundings involve (from above, from the side, from other's work)*
- *What do you use your hands for- What do you work with?*
- *Are there any particularly hazardous conditions in this workplace*

By focusing on these primary risk situations one at a time, the risk evaluation becomes manageable, as one e.g. for “where one has one's legs”, shall evaluate the risk for 1) falls from heights and 2) fall to a lower level and first thereafter can go to the specific hazards 1-16.

5.1.2 Safety barriers and risk observations

The WORM project differentiates safety barriers on three levels, cf. figure 20 and figure 23:

1. Primary Safety Barrier, PSB
2. Support Safety Barrier, SSB
3. Probability Influencing Entity, PIE

In many cases the primary safety barriers are abstractions or generalisations of the “support” safety barrier, and most are not “visible” to users of the calculation program.

In DanWorm there has been a simplification and collection of the most important safety barriers, which primarily constitute the supporting safety barriers as the “support” safety barriers can be described more concretely in relation to observations. Likewise, a selection of the quality parameters has occurred, which are the most important in relation to influence of the likelihood for accidents.

Diagram 22 shows an example of how these terms are handled for the activity “Work on moveable ladders”.

Diagram 22

Hazardous activity	Primary safety barriers (PSB)	“Support” safety barriers (SSB)	Quality parameters: ” (PIE)
Work on moveable ladders/fall from heights	1. Strength: ladder	Ladder type and/or state	Are there measures against skidding with the aid of non-slip or anchoring?
			Does the ladder reach less than 1 metre higher than the desired work or climbing height?
			Are the steps kept free from dust (such as mud, oil, paint, snow, ice, etc.)?
			Is it an industry-produced ladder for professional use, with a valid approval seal?
	2. Stability: ladder	Placement and safety	Is the ladder on a tilted or uneven base?
			Is the ladder anchored at the tope, possibly when the ladder has a steep placement?
			Are measures taken to prevent the ladder from sliding out at the base, possibly because it is far away from the wall?
			Are moveable ladders longer than 7 metres anchored?
			Is the ladder protected against blows from doors, etc. pushes or being driven into?
			Is there a warning sign informing that work is being carried out on ladders?
	3 Stability: user	Ability	Is the body position according to instructions (standing on the ladder side, feed not in the middle, face turned away form steps)?
			Is the user (sick, faint, under the influence of alcohol, drugs or medication) or equipped (shoes without profile, or muddy) not in good condition?
			Does the user not use hands as support (e.g. because the user is carrying a load)?
			Does the user not behave appropriately while on the ladder (e.g. standing on the ladder with both hands free, moving of extending the ladder while one it, to slide down without using the steps, hanging out on the side)?

Diagram 22 shows an example of the division between primary safety barriers, supporting safety barriers and quality parameters

An evaluation of the safety barriers is achieved by observing and evaluating the quality parameters. In a concrete case, a single quality parameter is evaluated at a time. It is either “in order” or “not in order”. There is no evaluation half way. Note that a defective quality parameter does not directly involve errors on a safety barrier, or lead to an accident, but it increases the likelihood for the safety barrier failing, and through this a dangerous situation occurs.

By observing the same activity several times (for the same employee, for a company or for a whole industry) one receives a distribution of how often a quality parameter is “in order”. The average of this distribution can be used to evaluate the likelihood of an accident (for a company or industry).

The control situation or standard of reference is the observed Dutch accident frequency in combination with the Dutch average distribution of quality parameters, based upon the Dutch questionnaire studies.

5.1.3 INFO card

Presented here are 2 x 17 generic INFOcard targeted, respectively, toward the employer and the employee.

The background is an understanding of which duties rest upon the employer and those that necessarily must rest upon the employees, who have significant independence in their work.

The manager shall generally ensure that the necessary safety barriers are provided, used correctly, maintained and controlled. The safety barriers are fundamentally linked to equipment, procedures and competencies. That is to say, for example:

- That the employer shall ensure that the correct equipment is in place and in order, that employees know, how they shall use it, and are motivated for using it correctly, and that the employee knows what he must do, when and if the equipment fails or does not suit the task.
- The employer shall organise the work so that there is clarity over what he expects of the employee behaviourally, that the employee knows this and is motivated to fulfil these expectations.
- The employees shall pay regard to the competencies the individual has when organising the work, and he shall take part in improving these competencies, when this is needed out of regard to the job's performance.

That is to say, that the employee shall ensure himself:

- That he knows which safety barriers shall be in order before he starts working.
- That he has the correct equipment and knows how it shall be used. He must also be motivated to use it.
- That he knows procedures and the manager's expectations for carrying out the work, and finally have acquired the necessary competencies.
- That he takes part in communicating with the employer, when equipment, procedures, working conditions fail, or are not in order, so that a solution can be found that is safety-wise in order.

Both the employer and the employee shall be familiar with the concrete safety barriers linked to the individual types of risks and these safety barriers function, and the consequences this has, if they are not in order.

The concept for filling out the 2 x 17 INFOcard is built up on the generic safety barriers for the individual risk areas and with 3 main questions that have the purpose of observing, evaluating and acting on the quality parameters, and which tell how good or how lacking the safety barriers are. The 3 main questions are:

- What shall be observed, which concerns observation of safety barriers
- How shall the observed safety barriers be quality assessed
- What types of action shall be taken based upon observations and the evaluation

Figure 43

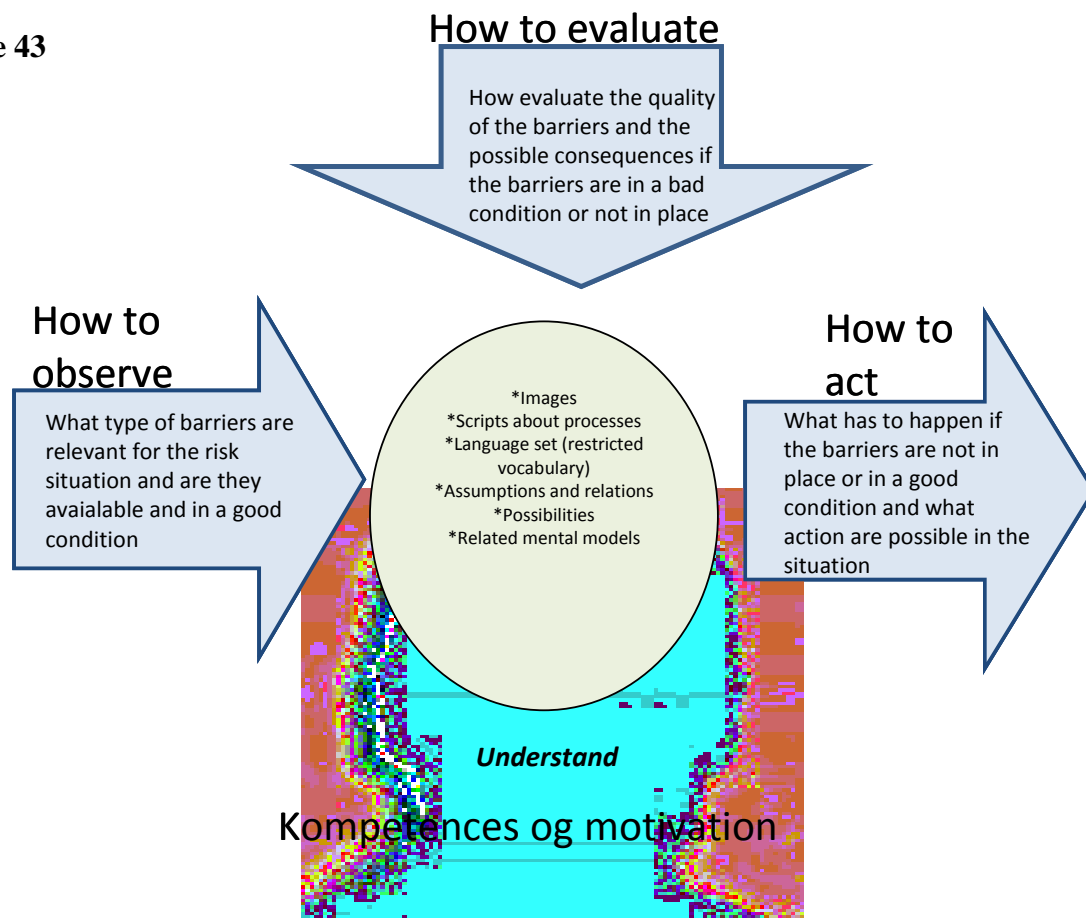


Figure 43 illustrates the concept for situation-determined attention, which forms the basis for the structure of INFOcard.

For the individual risk types there will be a number of conditions, which both the employer and employee shall be in a position to observe, evaluate and act on. That is to say, both parties shall be able to observe the necessary safety barriers and understand what meaning they have to safety, and which action possibilities there are at their disposal.

The difference is, that the employer shall observe and evaluate beforehand without necessarily knowing the concrete situation and at the same time act by ensuring that the equipment is in order, etc. and at the same time ensure that employees have the knowledge, competence and possibility to observe, evaluate and act correctly in the actual situations they come into.

The employee shall be able to observe, evaluate and act in the situation without his employee being present. I.e. he shall be able to act independently but based upon the guidelines that the employer has set forth.

The presentation of the 2x17 INFOcard in appendix A is the following:

- a) Introduction of the risk type and associated hazards and safety barriers, including exemplifications and concretizations retrieved from the 2 industries described in chapter 4.
- b) INFO card for the employer.
- c) INFO card for the employees.

The content in these INFO cards is taken from the list of all hazards, their safety barriers and associated quality parameters.

5.2 Risk assessment and calculation

The DanWorm project has, during its project period, cooperated closely with the Dutch project and had an influence on the user-friendliness of the software in the ORCA light version.

The DanWorm project has also secured a Danish version of the Dutch software program.

5.2.1 A Danish version of the risk calculator "ORCA"

ORCA stands for Occupational Risk Calculator Assessment. Fundamentally, ORCA is a program that makes it possible to calculate the risk of being subjected to a fatal accident, accident involving invalidity or other accident with a severe but recoverable injury.

ORCA is available in two versions. The first version is a "stand-alone" application, which is the latest development of the WORM project. Described in section 5.3.2 is how the DanWorm project has developed some interfaces to the "full" ORCA program with its major requirement for input with a view to simplifying this input.

The WORM project has also developed a simplified web-based system- Web Orca, www.weborca.nl - which is a light version of the full ORCA, inspired by the simplifications that DanWorm has developed. This web version is also available in Danish.

But in order for the calculations to be done, it is necessary with a number of details about the work one wants the calculations performed for and the conditions under which this work is performed.

Input to Web ORCA

The details that are needed to enter into Web ORCA are:

- Statement of which trade groups that are included e.g. in a company
- Statement of the number of persons that are included in each trade group and how many are over the age of 50.
- Details about their working hours with hours per day, days per week and weeks per year.
- Carried out for each trade group was a division of the tasks that each individual trade group performs. The intention of this is to have demarcated concrete job tasks that can be evaluated for hazards, and for exposure time and quality of the safety barriers.
- The requirement is that there is a statement of which risk situations/hazards, the individual task contains, as one can chose from a step-by-step selection of hazards in the 4-17-64 grouping.
- Also required for each task is a specification of what scope, time spent, the task is performed by a % of the total working hours.
- The requirement is final, that an evaluation of the quality parameters for the safety barriers occurs, which the system finds on the basis of the details of what hazards have been

specified. Used here is a simple 5-step scale going from “poor-unreliable-average-outstanding”.

In other words, quite a few details are needed, about the entire company, as well as about the individual employee and his specific tasks.

Output from Web ORCA

The results one can obtain from Web ORCA, are a calculation of the likelihood of a workplace accident occurring, with a consequence of either death, invalidity or other severe but recoverable injury.

Information will be given about the entire company, as well as for the individual trade groups and the individual tasks.

It is also possible for the user to specify their own acceptance limits, after which they will be included in the display of likelihood calculations with the colours red, yellow and green for how severe the risk is in relation to the given acceptance limits.

Furthermore, the system contains details about the Dutch national average for the relevant trade groups, which one can compare oneself with.

The last level in ORCA is an “Optimiser”, where the system informs about the initiatives it will be appropriate to perform in order to change the risk image and what these initiatives cost.

Thus, the final result is a diagram showing the actual calculated risk stating which initiatives that are financially most appropriate to carry out cf. figure 27.

With this, a basis is given for prioritisation and decision making in a management system for safety.

Web ORCA – Danish version can be found at <http://weborca.nl>, where a password and username can be requested (this page is available in Dutch and English).

5.2.2 Risks at industry and trade group level

Compiled in the Dutch material are a number of general tables for industries, trade groups and hazards, which show the exposure conditions in The Netherlands.

Under the assumption that the working conditions and risk situation within industries and trade groups in The Netherlands correspond to the conditions in Denmark, one can here gain a general risk picture, which it has not previously been possible to draw up.

5.3 Risk observations and results from two trade groups

As described above, the use of ORCA requires many detailed pieces of information before the calculations of the accident risk can be carried out. The DanWorm project realised early on that especially small businesses would never be able to find resources or motivation to use such an electronic system, among others, due to the requirement of the large amount of information. The idea was, therefore, that others could gather information for a number of employees and thereby create the basis for an average calculation of risks for e.g. a certain trade group.

In connection with this idea, an aid was developed for recording data, in the form of a little software that can be downloaded onto a PDA. With the help of this tool, it was possible to follow a person

throughout his working day and record his tasks, risk situations, exposure time and the quality of the safety barriers, all together in an electronic form where data can be transferred directly to a PC.

5.3.1 An electronic tool for risk observation

The method for mapping out the risk of workplace accidents, which is described in the above section, is built in an electronic registration tool. The system consists of a PDA (handheld computer), that runs a program based upon Microsoft®Windows Mobile™ version 5.0. With the aid of the program, data can be collected (scoring) which can subsequently be transferred to a normal PC for further analysis and processing.

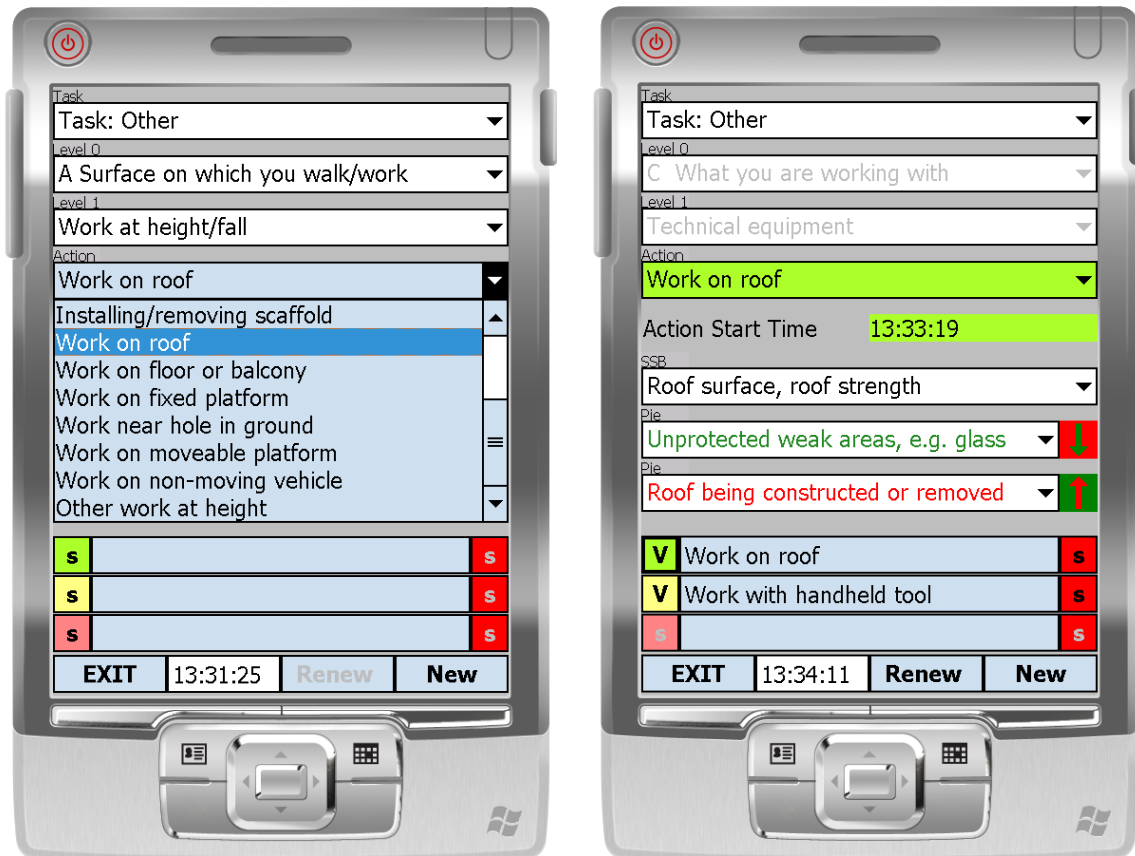


Figure 44 Example of PDA screen while recording activities, hazards, safety barriers and quality parameters

The program leads the observer step-by-step through the structure for risk observation. The data collection basically is comprised of one selecting the activities, in “real time”, that the observed person performs, i.e. one “notes” the beginning and end of the activity. For each observed activity, each safety barrier and what deficiencies one observes among the quality parameters can be noted.

The procedure under the observation is illustrated with the aid of screen shots of the PDA in figure 44. In the example, it is about a caretaker who is performing the task “Building maintenance”, which is stated in the top line in figure 44 to the left under "Task". The next lines show how one, with the aid of the structure in 4-17-64 risk situations finds it or the relevant activities the relevant person is in the process of performing.

One can select up to 3 simultaneous activities. The PDA's rolling menus go down from the general characteristic (Level 0) "A: Foundation, where walked, worked" via the activity/hazard (Level 1) "A1, Work at heights/(risk for) fall" to the concrete "bowtie" (Action) for "Working on ladders" (and the screen informs us that this activity is registered as being started at 12:34:53).

When a concrete activity is selected, one must subsequently register the quality of the safety barriers that are relevant to the concrete activity. The line under "Action Start Time" contains precisely the safety barriers that the chosen activity need in order to be evaluated. Again there is a scrolling menu, that can show the relevant safety barriers and one can choose them one at a time and perform the evaluation.

The evaluation itself is performed with the use of the green-red lines. The chosen safety barrier's quality depends on a number of quality parameters, and on the two lines one indicates which quality parameters are "in order" (the green line) and which are "not in order" (the red line).

The program is constructed so that all quality parameters are per defaults "in order", so one must actively choose the quality parameters that are not in order and move them down to the red line.

One can shift quality parameters with the aid of the arrow keys to the right of the lines.

It can keep track of three¹ simultaneous activities/hazards under the same task (one can only be occupied with one task at a time). The active activities/hazards are shown in the three bottom lines. It is possible to change the quality parameters once an activity/hazard is activated.

5.3.2 Preparation and analysis of PDA data

For observations and analysis of data several computer programs have been developed. The programs are enclosed on the report's CD and contains a help file (in English), which describes the program functions and effects. The same helpfile contains a step-by-step description of the installation of the PDA application and how the PDA program shall be used.

The PDA application requires a program, "DanWORM score" and two data files installed on the PDA system. These data files contain, respectively:

- 1) The description of ORM's activities/hazards, safety barriers and quality parameters
- 2) Definition of the tasks, which are specific for the job to be analysed and observed.

These files can be edited with a PC program "DanWORM PrepareInput". The first data file is structured according to the "4-17-64" principle.

The PDA program saves the scoring in a file, which must be transferred to a PC for further analysis. For this purpose, another PC tool, "DanWORM Analyse Score" has been developed. This program permits scores to be visualised, which can be used for quality assurance of data: the time elapsed of the tasks and activities are shown as a function of time.

¹ In theory one can be subjected to more than three "bowties", but based upon practical considerations, both with respect to the observer and layout of the PDA screen, the tool is limited to three.

The program puts scorings from different observations together with a view to generating different averages of data, and in the scope it is possible, statistical variance of this data. One can choose to combine data for individual persons, individual companies or for an entire industry.

The most important result of the analysis is for each defined, job specific “task”:

- Time spent on the task;
- Which activities/hazards are included in the task and what percent of the time they constitute (the total sum of percentages can exceed 100%, i.e. that actions may overlap each other);
- For each quality parameter that is related to the above activities, it is counted how often (frequency) and how long (time) a quality parameter was not in a correct state – this leads to an average score for these quality parameters based upon the frequency or time, corresponding to ORM’s “Dutch National Average-DNA”
- The same analysis of quality parameters is also performed as a total average for all tasks (i.e. that a quality parameter status exists, both per task and as a “job average”)

The program can export data to CSV files (which can be used in normal spreadsheet programs such as Excel), but it can also generate an MS Access database which is used in the program “DanWORMLight”.

DanWORMLight is used to define an input data set for the Dutch ORCA program (ORCA=Occupational Risk Calculation). It simplifies the data input in the way that the user must only enter the time spent on the tasks. With the aid of the average distribution of activities/hazards per task (which is generated on the basis of observations with the aid of the “Analysis” program), DanWORM-Light calculates the exposure for the different activities.

The program also generates a risk profile but it is only based upon the Dutch average (DNA) for the quality parameters. Afterwards, ORCA can input the project file produced by DanWorm light for a closer specification of the quality parameters and for calculation of the optimal safety measures. Figure 45 shows the schematic connection and results of the different tools and data.

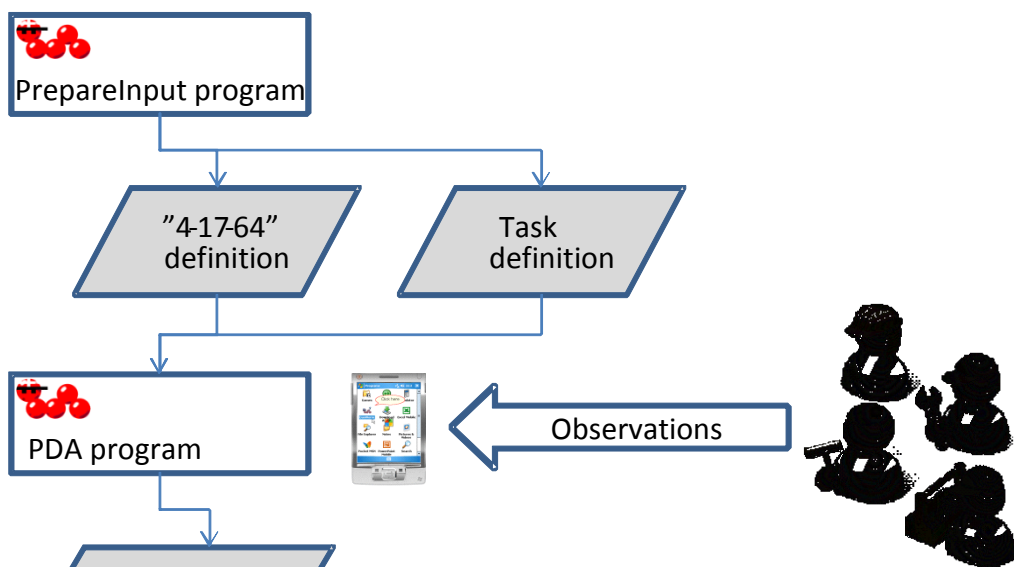


Figure 45 Tools for analysis of the observations. DanWORM tools are marked with the DanWORM logo. Grey box is data generated with the aid of DanWORM tools. Pink box is tools or data from the original Dutch WORM projects. Boxes with bold edges can be understood as end results from DanWORM's observations.

5.4 Results from 60 observations in two sectors

The result of DanWorm project's data collection among respectively carpenters and caretakers is presented here.

5.4.1 Time utilisation for tasks

At the same time as the electronic collection, the observed persons were asked to state, how much of their work time they expected to spend on the individual tasks. In some cases, the "Master" also

made an estimate for the employees in his company- The results are shown in figures 46-49. Figures 46 and 48 show the average time spent according to the study person's own expectation and the time spent when they were observed the few days the observations were carried out. There is a surprisingly good agreement between observation and expectation, especially in light of the individual study person's expectations varying greatly as shown in figures 47 and 49.

The figures show the average plus/minus a standard deviation (i.e. 60% safety interval). The large variations are due to the fact that there is a great difference between the activities that the businesses or the employees are employed with. This points to the risk analyses preferably being based on a company or personal level.

Remarkable is the difference between own expectation and the observation of “Other tasks and breaks”, especially with regard to caretakers. This is explained by the employees having more breaks underway, which according to their own perception are included in other activities. This points to that data collection based upon reflection of own work (which forms the basis for the Dutch WORM project) can contain some systematic deviations from practice.

Figure 46

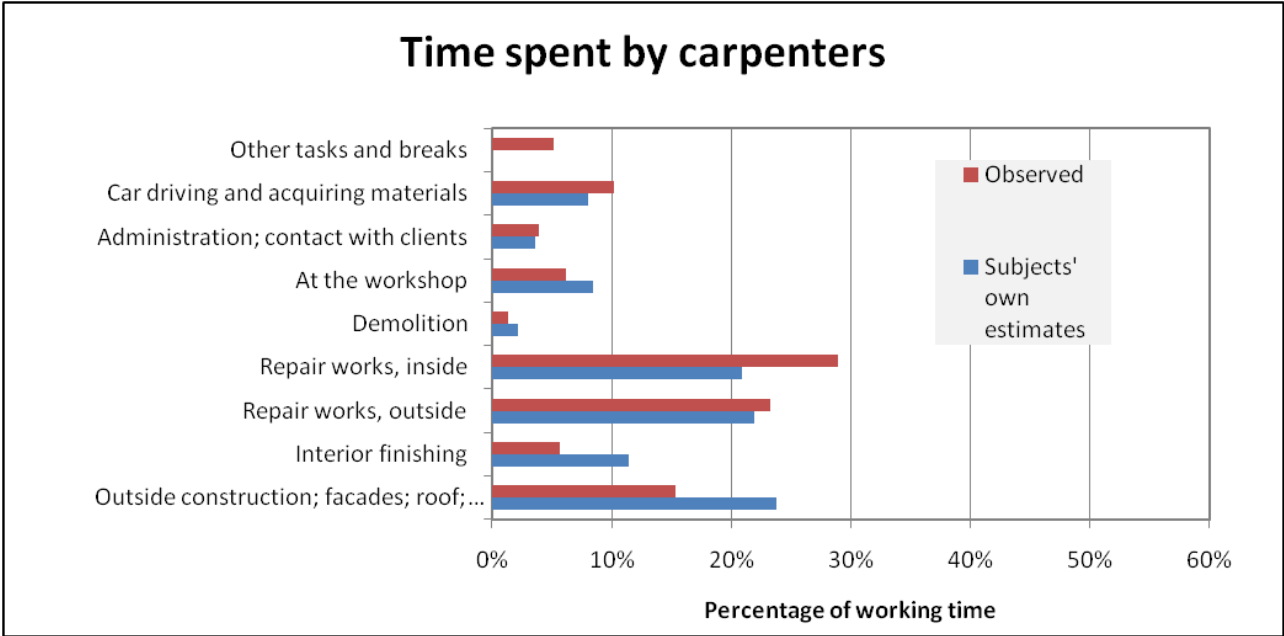


Figure 46. Time utilisation for carpenters of the carpenter trade's specific tasks, stated according to their own expectation (based upon one year) and stated after the registered observations (based upon 467 observed working hours).

Figure 47

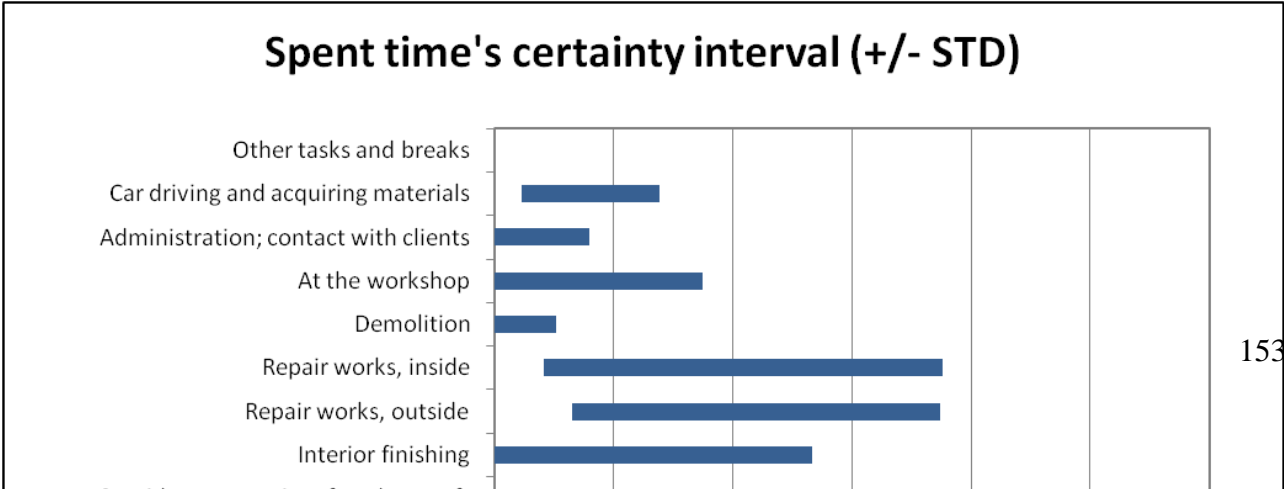


Figure 47. Variation in the carpenters' own expectations for time utilisation for one year of work.

Figure 48

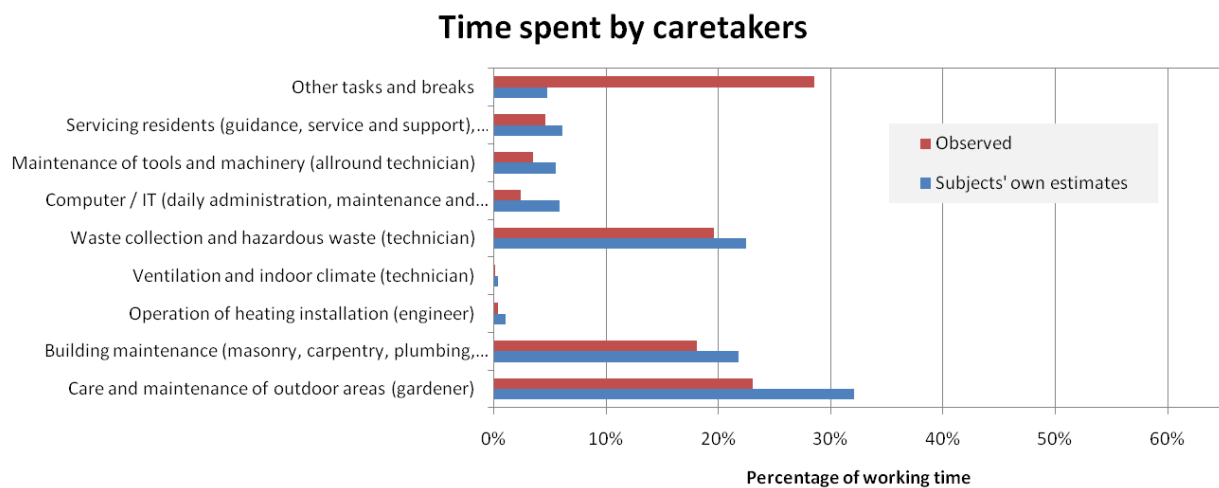


Figure 48. Time utilisation for caretakers on the caretakers' specific tasks, stated according to their own expectations (based upon one year) and stated after the registered observations (based upon 355 observed working hours).

Figure 49

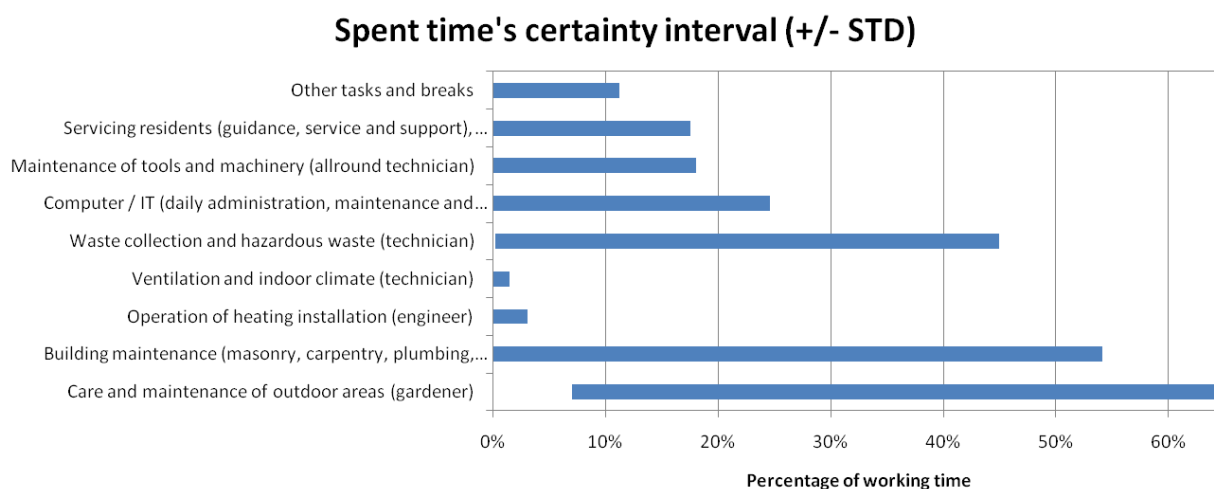


Figure 49 Variation in the caretakers' own expectations for time utilisation for one year of work.

5.4.2 Activities that are included in job-specific tasks

With the aid of the observations it was possible to gain an impression of how often and how long the workers become exposed to the dangers, which WORM has defined via the 64 hazards, while they perform a job specific task. For each of the tasks that were identified for carpenters, respectively, caretakers, a "standard exposure" has been achieved. Standard exposures are shown in figure 50 and 51.

These standard exposures are placed in input data for the software tool "DanWORMLight". This tool makes it possible to simplify data input from an evaluation of 64 hazards at a fraction of time of the 8 to 9 job specific tasks.

Both for carpenters and caretakers the normal "movements" are the most frequent activity for all job specific tasks.

Figure 50

Carpenters' exposure

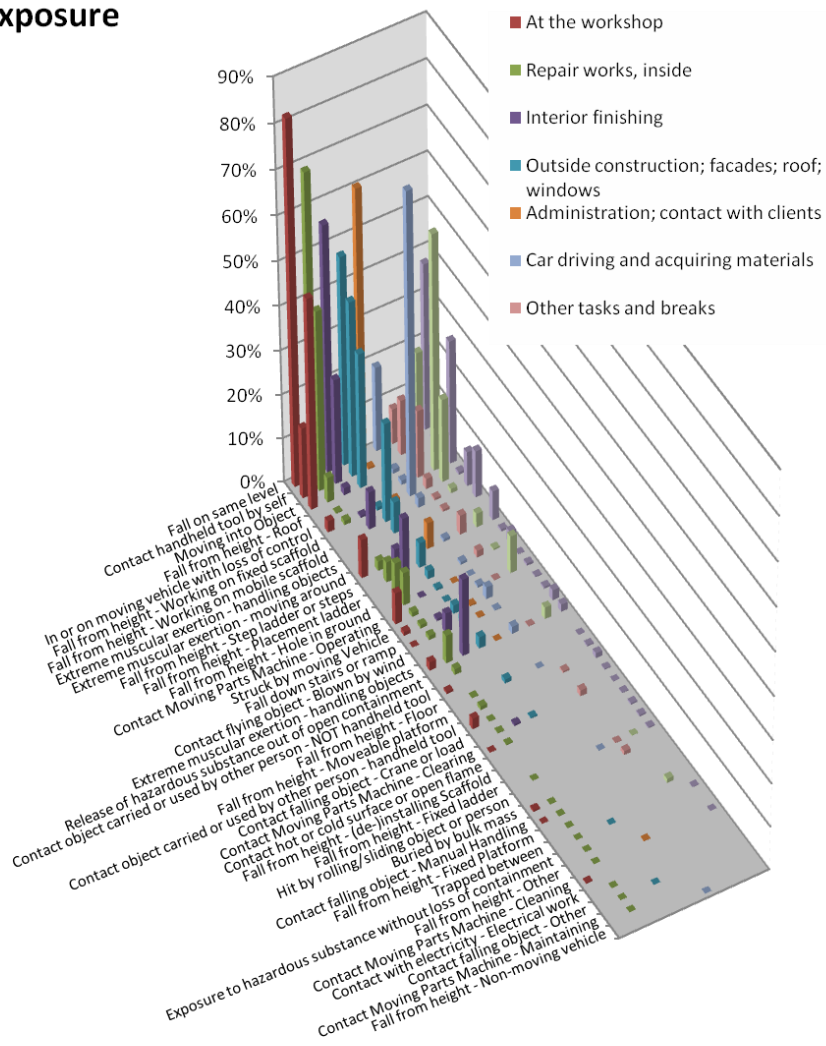


Figure 50 shows an overview over exposure for the different job specific activities/hazards for carpenters.

Figure 51

Caretakers' exposure

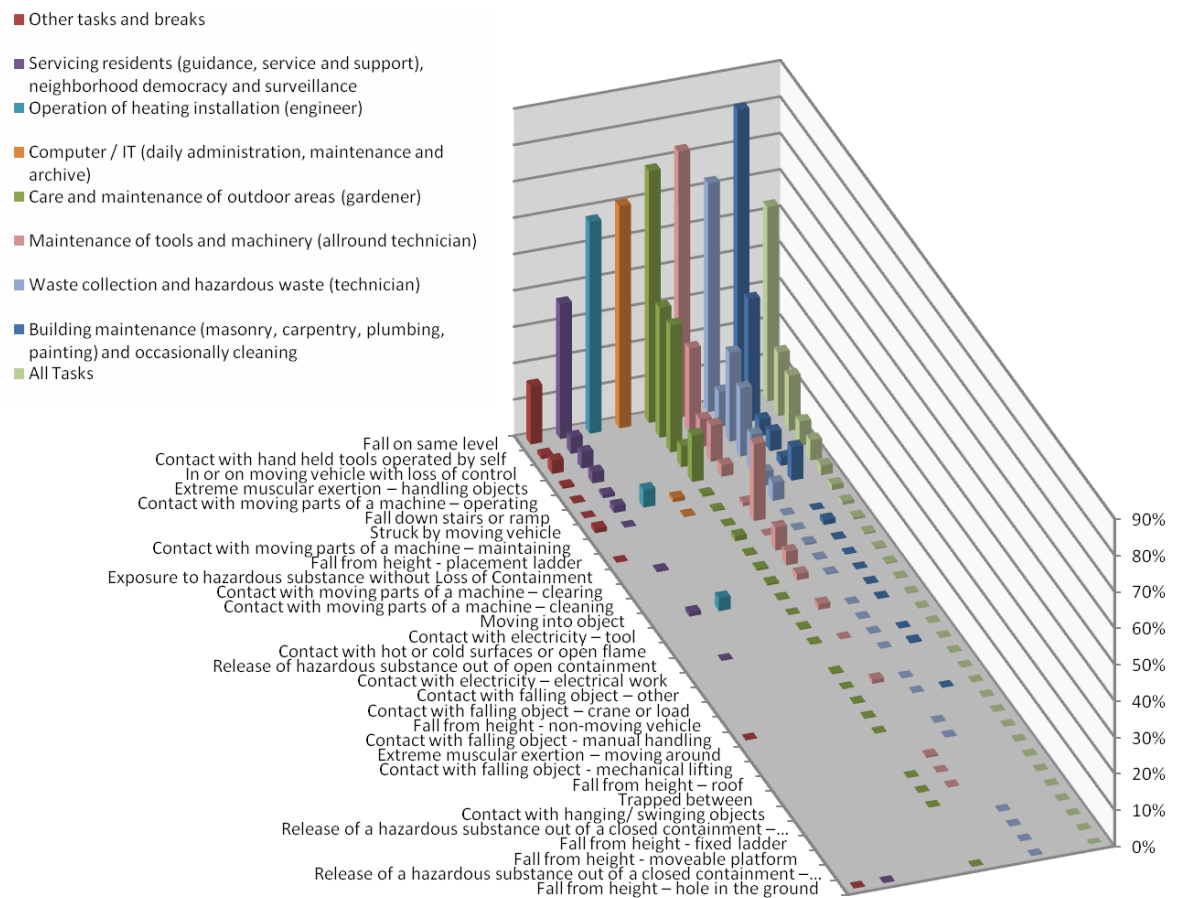


Figure 51. shows an overview over exposure for the different job specific activities/hazards for caretakers.

5.4.3 Observation of the quality parameters of the safety barriers

The observation also contains an evaluation of the safety barriers quality parameters i.e. that it is noted when a factor that affects the safety barrier is not in a satisfactory state. The purpose is to investigate whether the statistic for these quality parameters will deviate from the Dutch national average (DNA). The number of observations is, unfortunately, a limiting factor for achieving statistically significant results. Observations for carpenters include, in principle, more than 600 quality parameters. Of these, it is only possible for 35 to show an average factor that deviates from 100% (which is the default value of the observations). These 35 factors are shown in diagram 23. The values for the quality parameters are worked out both with regard to the number of times an activity begins and the total time that an activity is carried out. As the time, which an activity is performed for, can be different, the results are also slightly different.

Under the observations it has also been attempted to evaluate the carpentry businesses' safety equipment and safety culture. The assumption was, that the company with a good safety culture would show a higher average quality score. This connection could not be proven.

In light of the lack of statistic significance for most of the quality parameters, they are not used in the further analyses.

Diagram 23

Activity	Secondary Safety barriers (SSB)	PIE factor	PIE value	
			Based upon time fraction	Based upon the number of events
Work with hand tools	Working subject's state	Placement and adherence of subject	99%	97%
Work with hand tools	User ability; placement	non-awkward positions	80%	81%
Work with hand tools	Personal protective devices (PPE)	Use of PPE	96%	93%
Work with machines	Physical safety barriers 2	Complete shielding of moving machine parts	91%	90%
Work with machines	Physical safety barriers 2	Presence of safety equipment	95%	95%
Work with machines	Control over movements and attention	Marking and signal for danger zones	86%	92%
Work with machine	Machine's integrity	CE labelling	81%	93%
Work with heavy/bulky objects	Position	Positions	98%	95%
Work with heavy/bulky objects	Technical aids	Aids in poor state	89%	95%
Work on fixed scaffolding	User ability	Scaffolding floor clean and tidy during the course of the work day	86%	94%
Work on fixed scaffolding	Railings	Sufficient railings fixed to scaffolding	89%	90%
Work on movable ladders	User stability; behaviour	Use of hands for other than holding on	48%	71%
Work on movable ladders	User stability; behaviour	Appropriate position on the ladder	87%	94%

Activity	Secondary Safety barriers (SSB)	PIE factor	PIE value	
			Based upon time fraction	Based upon the number of events
Work on mobile scaffolding	Own erection of scaffolding	Used brakes	79%	83%
Work on mobile scaffolding	Own erection of scaffolding	Measures against the scaffolding rolling away	80%	84%
Work on mobile scaffolding	Railings	Sufficient railings	46%	53%
Work on ladder stairs	User stability; behaviour	Appropriate position on the ladder	0%	0%
Work on ladder stairs	User stability; behaviour	Use of hands for other than holding on	75%	83%
Work on ladder stairs	User stability; behaviour	Appropriate position on the ladder	83%	89%
Work on ladder stairs	Placement and securing	Placement of ladder at foot	0%	0%
Work on ladder stairs	Placement and securing	Placement of ladder at top; angle	0%	0%
Work on ladder stairs	Placement and securing	Good placement of ladder by foot	94%	96%
Work on roof	Fall securing (5 PIES!)	Use of harness	73%	61%
Work on roof	Railing	Railing in place?	85%	83%
Work on roof	Roof's surface; carrying capacity	Roof under construction or demolition	37%	36%
Work with holes	Covering strength	Covering of holes	13%	34%
Work with holes	Railing	Railing	71%	54%
Work with/with open containers containing chemicals - spill	Containers placement and protection	Placement and handling of container; especially handling and manner of placing on	37%	38%
Activities	Surface's state	Holes; disorder; edges;	89%	92%
Activities	Surface's slipperiness	Loose things; slip increasing	98%	96%
Activities	Presence of obstacles	cables; materials; equipment	68%	71%
Activities/work with limited freedom of movement	Control over movements	Disorder; mess	57%	62%
Activities/work with limited freedom of movement	Control over movements	State of surface; holes; step	81%	87%
Activities/work with limited freedom of movement	Equipment; object state	No suitable entering and alighting facility	95%	92%
Stay/work in/on vehicle	Driver's ability to drive	Attention	96%	94%

Diagram 23: Barrier quality factors (PIE value) that are significantly different from the default value (100%) for carpenters.

5.4.4 Risk analyses for carpenters and caretakers

With the aid of the software tool “DanWORMLight” the risk profiles are calculated for caretakers and carpenters based upon the average expected time expenditure for the specific tasks and the observed exposures for these tasks. Figure 52 shows the result for carpenters and figure 53 for caretakers.

These figures are limited to the 20 activities/hazards that contribute most to the risk, where the risk is weighted: the risk of death and permanent injury is weighted with a factor 100 respectively 10 in relation to the risk of recoverable injury. This means that the choice of the most important 20 activities is not sensitive toward the choice of these factors.

In comparison with the exposure, these risk profiles are, to a higher degree, determined by the most “risk filled” activities, even the normal “activity” is the most frequent activity, it only contributes to a minor degree (on respectively 9. 9th and 6th place) to the carpenter’s and caretaker’s risk.

Figure 52

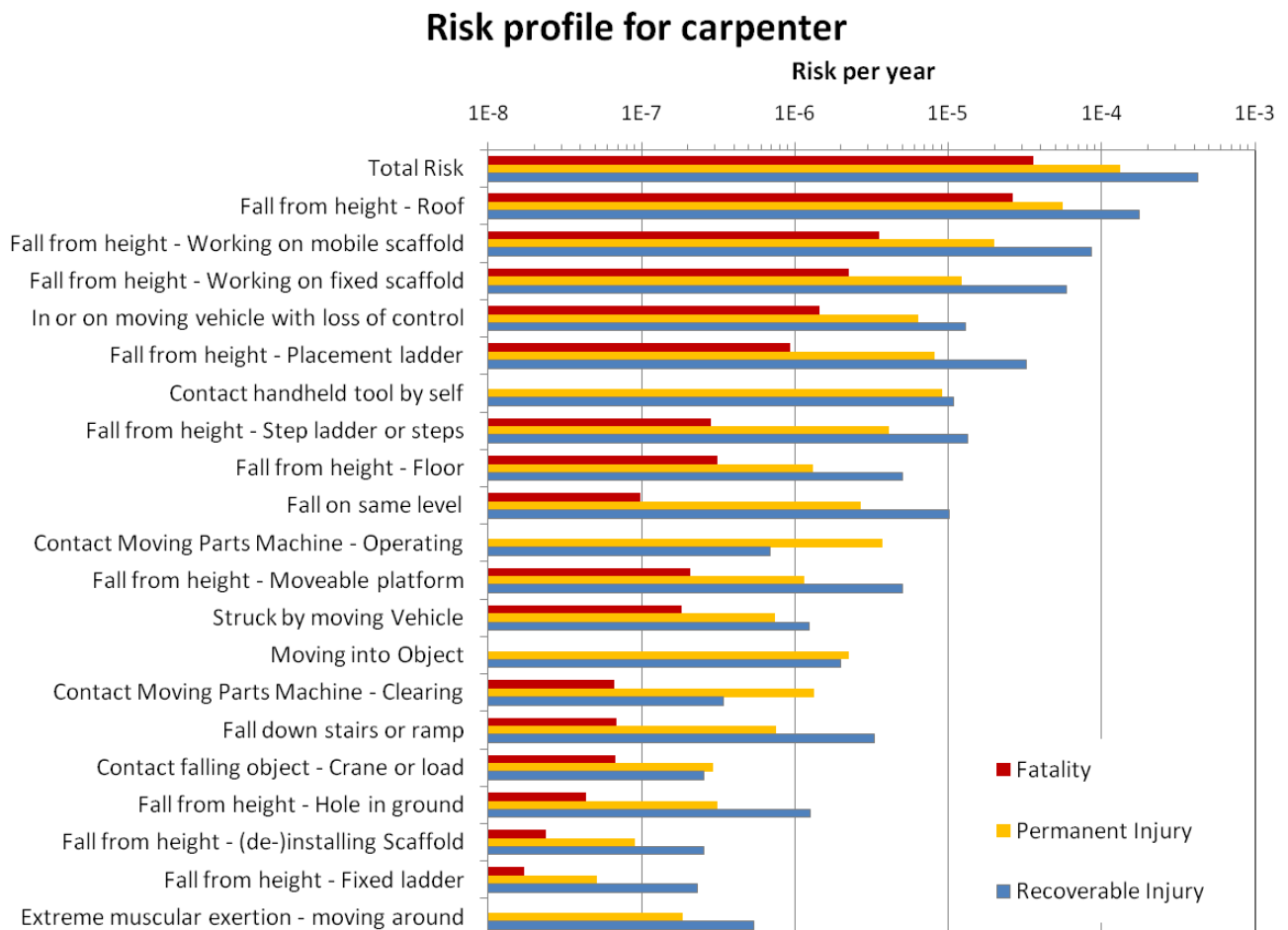


Figure 52 Risk profile for carpenters based upon the anticipated time spent and observed exposure.

The figure is limited to the 20 activities with the greatest contribution to the total risk.

Figure 53

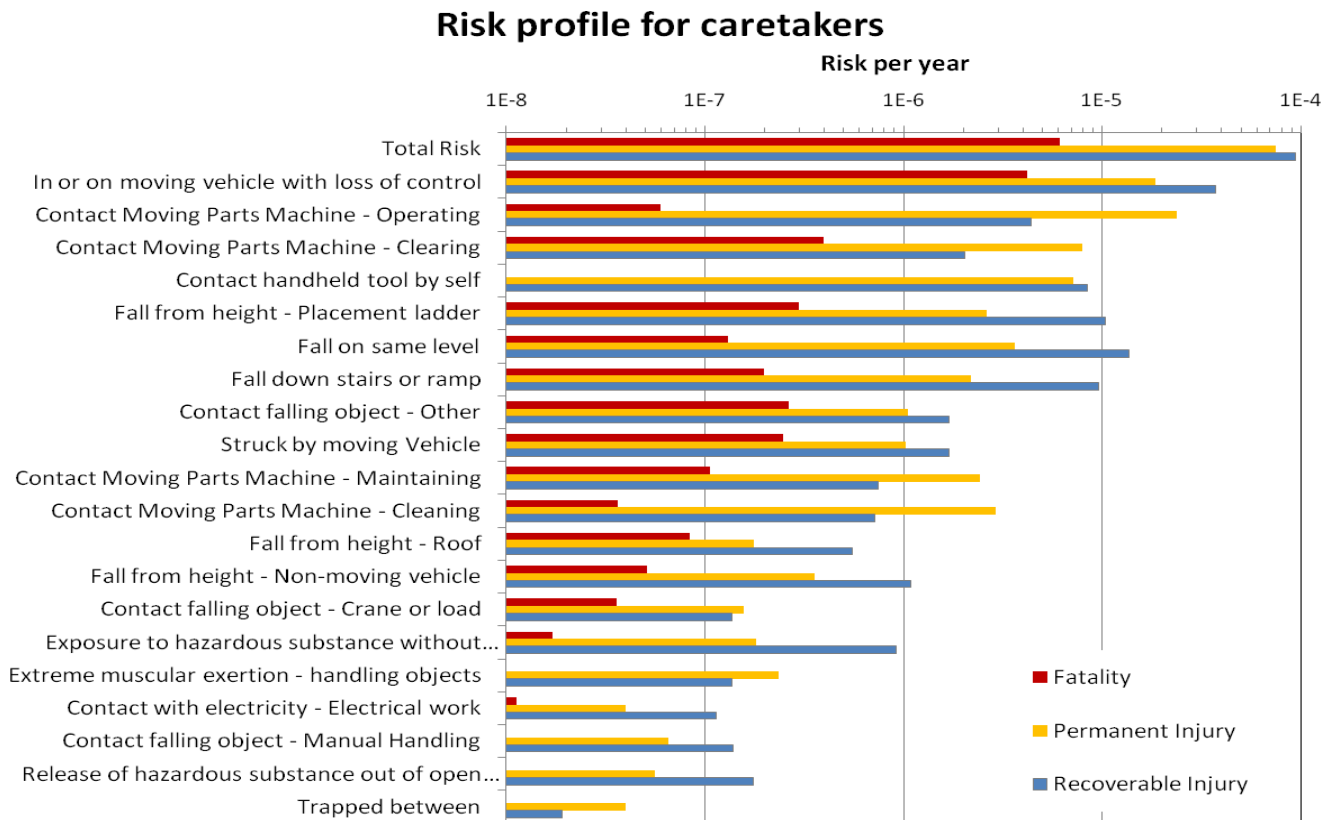


Figure 53 Risk profile for caretakers based upon the anticipated time spent and observed exposure. The figure is limited to the 20 activities with the greatest contribution to the total risk.

5.5 Summary

This chapter presents the immediate results that the DanWorm project has developed. These results can be regarded as basic tools that can be used for risk assessment and to create safety. How this can occur is presented in chapter 6.

The developed tools are:

1. A systematised overview of the hazards that lead to accidents. Systematisation in the 4-17-64 model gives an clear method to work with the many types of hazards, which can give rise to an accident. It is the systematisation and clarity that are in the centre here.
2. Also, knowledge is obtained from the Dutch WORM project about the generic safety barriers that are linked to the individual hazards, and the quality parameters that are determining to how good or poor the individual safety barriers are.
3. Based upon this systematisation and knowledge INFOcards have been drafted for both the employer and the employee about what is important to observe about the safety barriers,

how they shall adapt the observed information, and how they should act when the conditions are not in order. For the employer it is about observing and acting beforehand, while for the employee it is about being able to evaluate one's own work situation at any concrete point in time.

4. The Dutch WORM project has developed an electronic system for the calculation of the risk of death, invalidity and other serious accidents – ORCA. The Danish project has contributed to making this system user-friendlier, ensured that there is a Danish version and made this available for Danish users.
5. The general analyses for the Dutch data, which is compiled in the Dutch Worm project about risks for industries and trade groups is also translated to Danish and made available through the Danish project. The data is unique; as it is the first time it has been possible to have knowledge about the exposure basis behind the accidents. This data is views as relevant in a Danish perspective based upon an assumption that the conditions in the Dutch and Danish workplaces are comparable.
6. The use of ORCA requires the collection of rather a lot of details about the tasks, job, activities, etc. To help with this data collection task, in the Danish project a small program has been developed for a simple PDA (hand-held computer). This makes it possible to follow a person in a job and record the concrete exposure conditions he/she is subjected to.
7. The Danish project has carried out a such registration for 20 carpenters and 20 caretakers, where is followed over 3 days, i.e. 120 days registration per trade. The details are subsequently transferred to ORCA, and a risk calculation is carried out.

The results from this are, among others, a risk profile for the two trade groups, as far as it applies to the two trade's tasks in a number of small businesses. Also developed is an aid that makes it possible to calculate an individual risk profile based upon the collected data and that only requires a fraction of the information in relation to the original ORCA tool.

These results give a fundamental knowledge about the risks and the immediate safety barriers that shall be in place in order to avoid accidents. But this knowledge cannot stand alone. One simply cannot just spread this knowledge out without being aware of how this knowledge will be received and used in the businesses. Without such an understanding the developed tools risk simply being yet another in the row of tools that no one quite understands how they shall be used.

6. Injuries are prevented by creating safety

The goal of the DanWorm project is to utilise knowledge regarding accidents and accident risks and knowledge about how one creates safety, so that accidents are avoided.

The results, that the previous section has arrived at are gathered in this chapter and set into a frame for their use.

6.1 Compilation of theories and tools for “safety creation”

In chapter 2 it was concluded that it is important that management in a company takes the question about creating safety seriously and that management prioritises this high in the company’s strategy and organisation. This applies not only to large companies, but also for small even if strategies and organisation here very often occur in a more informal manner.

It was also concluded that people’s ability to foresee when the concurrency of events that leads to accidents occurs is limited. One must instead look at the factors, that safeguard against accidents occurring. In that connection terms such as safety barriers occur and situation determined attention as conditions that can be used both to create safety and to evaluate the safety level.

The advantage of focusing on safety barriers and situational determined attention is that it is conditionate that either can be observed or asked about and therefore are suited as effort targets, training targets and evaluation targets.

The understanding of the barrier term is taken from the ARAMIS project presented by Hale & Guldenmund (2003).

The understanding of the term situationally determined attention has been taken from Endsley (2000). One method that is connected to the situationally determined attention is present through maps”, that Flin et al (2006) has developed. This way of thinking has meant the development of INFO card, presented in chapter 5 and shown in appendix A.

The idea behind the INFO Cards is to be able to tell both the employers and employees which hazards and safety barriers they have a responsibility for.

In the Danish study described in chapter 4, it shows that there are some things that necessarily must be done by the employer beforehand, which in addition to strategy and organisation include observations of both the technical safety barriers and the behavioural safety barriers. These include procedures, agreements, guidelines, motivation and communication to employees about what the manager expects with respect to the performance of the job safety-wise.

The Danish study also shows, however, that employees to a high degree have independent tasks of a highly varied nature and that they are often performed away from the employer’s home address or when their employer is not present. Such tasks require the employee to be able to evaluate his/her own risk in concrete work situations and act in relation to them. Furthermore, this also requires the employee to be prepared for the task both in relation to equipment, procedures, ways of doing things and in relation to the knowledge and will/understanding for what the employer expects of him.

The knowledge that exists from, respectively, the Dutch WORM project and the Danish DanWorm project is a knowledge of hazards, safety barriers, quality parameters, risk calculations and risk profiles, etc. But the question is how can one get this knowledge integrated into the employer's as well as the employee's competencies and attention.

Most would say that it is about building up a good safety culture in management, as well as for employees. The question is, however, what it will mean. One simply does not create a good safety culture without having both a method and an understanding of what the safety culture shall be targeted toward. It requires planning, prioritisation, organising and engagement from the side of management, who quite simply must want it.

On the other hand it also requires the knowledge about risks, that just the Worm results give. It is this combination of management concepts and knowledge about risks, which can ensure, that one has directed the attention toward accident risks in a systematic manner in order to create a good safety culture through this.

As it was concluded in chapter 2, one of the leadership methods that has especially shown safety-related results is to establish a goal, carry it out, check it and give feedback on how it went, to then set new goals, etc. For most companies, which want an improved safety level there is talk of a change management task. The principles in change management can therefore, with advantage, also be used in a safety field.

One must thus carry out initiatives in order to create a learning process for managers and employees. One must create a political process, where responsibility is placed and safety integrated both overall and in the daily work. Finally, one must create a symbolic process that contains histories, successes, visibility and clarification of the culture that is necessary in order to maintain a continuous high safety level.

In the following there will, therefore, be given an example of how the developed tools in the DanWorm project can be used. This occurs through a managerial level method of change and guidance as well as involvement and motivation of the employees.

6.2 Prevention in a change management and target management perspective

In order to increase the attention regarding risk and safety barriers within the chemical industry, in 2008 a management level concept was developed by Jørgensen and Bellamy (Bellamy et al 2008). This concept will be used here to illustrate how the developed tools can be used to identify risks, increase attention to risks and improve the safety culture.

The concept is based upon a coupling between change management (Kamp et al 2005) and Aims - the feedback system (Glendon et al 2007).

6.2.1 Aims and feedback as motivation to safety

To learn effectively it is necessary to be motivated. This motivation can be created from outside through rewarding or other encouragement/ incentives, or from inside through an own desire to perform work good and safely.

This safety related behaviour can be influenced by:

- Increasing the individual's confidence by performing the work in a safe manner
- By focusing on the individual improvements in relation to safety objectives

For this to be a success, however, it requires:

- That the goals shall be a challenge but absolutely achievable and
- That the feedback programme shall be precise and punctual.

Particularly important factors for achieving a good effect are:

- That it is obligatory to participate - it is something management requires and expects.
- That management clearly supports a development both through top management and through the daily management.
- That there is a steering committee to kick off initiatives, but that activities shall subsequently be integrated in the local units and employees.
- That training occurs based upon a relevant and clear programme.

The requirement for obligatory participation is to be preferred instead of voluntary participation, if it is appropriately organised. The goal is that employees, through participation, feel a personal control when they understand that carrying out observations and receiving feedback instead of creating a negative feeling and opposition. However, this depends completely upon management's practices and to what degree employees play a role in steering the process.

The visible support from top management and middle management is important. This means, for example, that the financial support for activities shall be guaranteed and the necessary time should be set aside for observations, analysis and the use of results. Management must also implement the changes that are suggested and that have an influence of working conditions and safety procedures.

It may be appropriate to start a change process by establishing a form of steering committee, who can kick off a programme and take the first steps in a decision making process. The choice of participants for a such steering committee must occur in a thoughtful manner and in such a way that employees cannot perceive this group as being something that has negative motivations. Also, it should be ensured that there is employee participation in this group. Finally, such a steering committee shall have the primary task of setting the process underway and being ready to let go of the reins when the local divisions and employees are ready to take over themselves.

It should be ensured that the training offered is relevant for the job and tasks carried out by the business and the working conditions that the employees work under. It is also important that the training does not contain elements of criticism or that blame is laid on employees, on the contrary, motivation and competence shall be created.

The training shall also focus on simple and relevant knowledge, which can continually be developed and that can support learning.

6.2.2 Change management in a safety perspective

According to the change management concept, the strategy for change should include the following 3 components:

- | | |
|---------------------|--|
| A learning process | where all that are involved gain knowledge about which safety problems one would like to have solved and in what way. |
| A political process | where the participants in the process are given roles and responsibilities possibly especially privileges and power and where a coalition of participants is established that shall measure the changes. |

A symbolic process where a new culture receives an identity through symbols, rituals, rewards, story telling and own language.

The learning process has a focus on how the organisation functions beforehand in relation to safety and the possibilities and conflicts for reflection and learning that the participants have in the organisation. Demand for change of the safety conditions opposite the participants, acquisition of new competencies for a safety related behaviour, change of the point of view on safety and risks, including methods and relationships, are necessary for a learning process. Key words in achieving a high safety level are a high degree of employee participation and that employees take ownership to achieve it through a number of learning activities.

The political process shall organise the change process in the safety area. The future organisation of the safety work should be looked into, where certain participants and groups or participants receive special privileged roles in the change process. In this way a coalition of special dedicated participants can contribute to supporting the process in the organisation. The content will be a form of co-operation that after a bit of time can become a natural way of doing things.

The symbolic process is to create a new identity for the safety work and for the change. The symbols can support a change process through the integration of new safety activities. This can be done through the way that they are expressed and the rituals that give the change in safety an image and status for different participants.

In this process it is crucial that management goes ahead and shows credibility toward the established safety targets, so that employees can have confidence in the management. This requires, among others, that the management follows the same rules that they demand of employees and a prioritisation of the safety considerations occurs, when situations arise that are in conflict with other prioritisations.

6.2.3 Awareness among the management

As stated it is completely necessary that management commits itself to wanting to achieve new targets for safety in the company and that it becomes a strategic goal for the company. This requires, however, that a consciousness is created in management that there is a problem and that the problem can only be solved through a change in the company in management as well as with the employees.

This insight can come due to a serious accident or by registering many accidents and the consequences that it immediately has for absence and costs to the company. It is not uncommon that the insight comes from a parent company, which due to an international strategic decision has a particular demand for safety level and performance. But the insight can also come from demands from authorities, customers, and the insurance system or from top management's own ideological manner of thinking.

But wanting to have a high level of safety is not the same as getting it, unless one understands why accidents occur and what is needed to ensure that the likelihood of accidents is minimised.

- It is about accepting that the accident risk is present the entire time but that it can be minimised through the maintenance of safety barriers, which includes technological, as well as organisational and behavioural measures.
- It is also about accepting that it is difficult to be able to predict all of the events that can occur and make an accident sequence possible.

- It is also about accepting that one cannot, at all times, be aware of the risks and possibilities for accidents and therefore demand a constant attention to extend, install, maintain, keep up and control safety barriers.

One can remove some risks, but one cannot remove them all. The risks that are present shall be identified and they shall be handled so they become adhered to on a level that ensures that the likelihood of unfortunate coincidences is minimal.

One of the accident risks greatest problems is that this attention and consciousness degenerates over time, when and if nothing has occurred for a longer period of time. It can dull the control by maintaining the safety barriers.

If many small accidents or near accidents occur, where “nothing serious happens”, it is in itself an expression for one not taking one’s own or one’s colleague’s safety seriously. It will also mean that accidents will occur, also with severe consequences. These can occur when no one has taken care of creating a high level of risk consciousness in either management or in employees.

6.3 Programmes to create risk awareness

6.3.1 Preparation of the programme

It begins with management making a decision to create a change in the safety area. The next step is to find out what risks there are in the company and which one must tackle first in a change process. This requires a survey, which can be carried out in different ways. One can hire external experts to perform a survey but one can also perform it oneself.

One method can be to go through the company task by task and check out the risks based upon a systematic going through of the 4-17-64 risk sources. Such a going through together with the employees who perform the tasks will be able to provide a systematic and good picture of the risks. These details can either be entered into ORCA, where a risk calculation can be made or one can also relate to the themes that the employee and manager find the most relevant to have tackled.

Another method can be to allow selected persons follow employees for a number of days and with the help of registrations in the developed program to a PDA, obtain a survey of activities and safety barriers. Thereafter the details are transferred to ORCA and a risk profile can be worked up.

A more simple way can be to be near the industry’s general risks and tackle the hazards that are shown in the industry profiles.

A survey created one way or another will provide a basis so that management can set its goals and its strategies for a change process.

The next step will be to establish a steering committee or similar to put the process in motion and to keep up with targets, strategies, processes and a monitoring of the necessary changes occurring.

As the change management concept requires, this steering committee should be comprised of management as well as employees and in such a composition that it supports reliability and confidence in the employees.

In companies where there are several leadership teams, there shall be an anchoring of targets and strategy through all of these management teams, so that everyone understands what it is about and ensures that the process is supported by top management as well as middle management. It is first

when an anchoring of safety consciousness is achieved in both employees and their daily management that one can expect to achieve a high safety level.

A change process about safety is a line management responsibility that cannot be transferred to, for example, a safety organisation. However, the safety organisation or perhaps a safety department manned by particularly safety conscious people can be a very good support to having built up the necessary competence in both management and employees. A safety organisation can also be an agency that contributes to carrying out risk mapping and a subsequent audit of target fulfilment, etc.

The last link in the preparation is that all become fully informed about the programme's idea, structure, target, and implementation. It is important that everyone understands their roles and co-operation in the programme, and their responsibility for its implementation. It also requires all manages being made competent in the knowledge about accident risks, safety barriers, quality parameters, including possibly with the use of INFO cards.

First when there is consensus and competence in managers as well as the steering committee, and all employees are informed about what management has decided in the way of goals and strategies can one tackle the change programme.

6.3.2 The programme's learning process

The goal of this part of the programme is to create an understanding for accident risks and safety barriers and the conditions one shall be aware of. It is also about how observations shall be used and what action possibilities one has. Here can one use INFO cards and their potential development.

The project proposes 4 steps (Steps 1-4), which all shall be carried out to ensure a whole and mutual synergy.

The goal of the learning process is to create knowledge, competence and awareness about the above named conditions. The learning process shall also secure the goals that are established within each individual programme step and the associated control and feedback system with expectation harmonisation and rewards for good performance.

Step 1

The first step is a training programme, which shall probably be organised by external experts or in the best case by a well-trained working environment co-ordinator from a safety organisation.

The purpose of the training programme is to present the content of the teaching process and of the more technical knowledge about risks, safety barriers and the conditions that quality determine the safety barriers. A motivation of the programme shall also occur. This can e.g. happen by showing the results of the survey and management's aim and strategy, as well as giving a general presentation of the entire course in the change process, so that all have as broad a knowledge as possible about what shall happen, how and why.

Management and employees should participate in the training in order to ensure that there is a dialogue between the parties and that everyone receives the same information. Also that management, at the same time, knows that they prioritise the change process that they have set in motion.

The result of this step is:

- That all have knowledge and understanding of the change process,

- That all know management's goal and strategy in the safety field,
- That all understand what risks are prioritised,
- That all understand what safety barriers must be in order,
- That all know and understand what conditions they shall observe continuously and how they shall act when they meet conditions that are not in order,
- That all know who has a responsibility for what,

Aim and feedback can be about how many have participated in the training programme and an evaluation of the training that was carried out.

Step 2

The second step is to have the newly acquired knowledge transformed into practice, e.g. by carrying out a type of "on the job" training. This training may necessarily be job specific and occur in a co-operation between manager and employee, possibly in a group of employees.

The task will consist in identifying the risks that quite actually occur in the tasks, occur in the daily work and presence of safety barriers, and an estimation of the quality parameters. This could, for example, be done by asking the following question:

- What risks from list 4-17-64 are there in the job generally,
- What safety barriers are in place and which are lacking,
- In what state are the safety barriers that are present,
- Are there particular situations where the risk is particularly difficult and where the safety barriers are insufficient/difficult to maintain,
- Have there been situation, where a risk has been close to developing itself into an accident, and what safety barriers were lacking,
- What risks and safety barriers are connected to the use of technical aids, processes, machines, etc.,
- What risks and safety barriers are connected to the organisation and the work's organisation,
- What risks and safety barriers are connected to the workplace, maintenance, cleaning, facilities, access potential, etc.
- What risks and safety barriers are connected to pressure of work, pressure of time, external conditions,
- What risks and safety barriers are connected to the a lack of information, guidance, motivation, co-operation, etc.

The answers to such questions can lead to a dialogue between employees and day-to-day managers about what changes shall be carried out by the manager and which observations the individual himself shall make to ensure that the safety barriers are continuously in order.

Through this dialogue, both a change of the working conditions and an increased attention to the concrete risk conditions can be created. Naturally, this requires that there is talk of a dialogue and that resources are allocated to carry out the changes the employees demonstrate there is a need for. Only in that way can the change process be made credible.

Aim and feedback must be about how many that actually carry out a proper “on the job” training, what changes it carries with it and an evaluation of the attention to safety that is created among employees. It is, therefore, both the manager and employee who are evaluated. Feedback can occur through a visible response to concrete measurements and a reward to those who especially do it well.

Step 3

The third step is to ensure that all have an easy access to the necessary information about the change process, risks, safety barriers, etc. Here, it is about ensuring that everyone can “remember” or have easy access to be able to remember what is now introduced. This means that the information shall be made accessible in a way that must be adapted to employees and be placed where the work is performed.

The necessary information is both aims and strategies, action plans, time and task plans, etc. but also job specific information about particular risks and particular measures. One can imagine that some information becomes a part of the work descriptions, a part of the building decoration, a part of the notice board or a part of the electronic knowledge system. It is important that employees participate in determining how they want the knowledge made accessible, so it fits into their understanding of what makes the work easy.

It shall be such that if the individual becomes in doubt about what was agreed or what risks there shall now be attended to, or who now has responsibility for what, he/she shall know where this information is and at the same time be able to have access to it in an immediately easy manner.

The same applies to all part aims and feedback results.

Aim and feedback must be about this information being made accessible and that all know where they can find the information and otherwise perceive it as being an easy access. Here it is the system’s function that is evaluated and the feedback is an ongoing communication of what new information is supplied.

Step 4

The fourth step is to constantly follow up the development and changes, not least through a registration of the accidents and near accidents that may occur. By mapping and analysing these cases in depth for the conditions that continue to lead to accidents occurring one receives an indication of where there are still problems with safety. Beyond the obvious, that action shall be taken for the concrete problems associated with the individual accidents, so can knowledge about the accident’s fundamental causes be used for a re-evaluation of what safety barriers are not in order and questions asked about the priority and targets, as well as any defects in the change processes implementation.

This will require that accidents and near accidents are registered and that they are investigated and analysed. Furthermore, it requires that feedback is given to employees about the results of the analyses and the actions this results in.

Aim and feedback is about this occurring and that action is taken on the results.

6.3.3 Political process of the programme

The goal of this process is to create an organisation in the company that takes responsibility for safety and risk consciousness in an interplay between management and employees. It is through this process that the work with safety can become rooted and made into a good tradition – as the way of working.

The project suggests 4 steps (Steps 5-8) as examples of how this can be done but many others can be used. The fundamental principle is, that a tradition is created to lead an ongoing dialogue about safety and risks in relation to the tasks that shall be solved.

Step 5

The first step is to involve employees in the changes that shall be carried out. This applies both to the changes that are a direct result of the change process in relation to the safety, but also other forms of changes, where e.g. new technology shall be purchased, changes to the working organisation made, or when external players shall be involved, etc. The purpose of this is to utilise the employees knowledge about how the work can be carried out, but also by obtaining a thorough analysis of the risks and safety problems one shall be aware of in relation to the changes that one wants carried out. By involving employees in this process and by involving their knowledge, one gets to a higher degree an ownership created to the change and at the same time competence in the employees and management.

The analysis can take a point of departure in the 4-17-64 hazards and the associated safety barriers. By going through possible risks and having a dialogue about which safety barriers are needed and how they shall be installed, used, maintained and controlled, one has a possibility for imaginary safety already in the planning stage.

Aim and feedback results will be that one has such a dialogue that one has a thorough analysis, and that the safety barriers one has reached and established.

Step 6

The second step is, that the day-to-day manager leads a dialogue with employees about safety and what risks, the individual shall be conscious of in the work that shall be performed the day in question. It is proven (Zohar 2003) that a ongoing dialogue about safety between day-to-day management and employees leads to a general higher risk consciousness and better safety related behaviour. However, it must be included in the daily dialogue in a natural and integrated manner. The dialogue shall be about the task, how the task shall be carried out, what risks it contains, what safety barriers, there shall be ensured are in place and eventually if there are safety barriers that are missing or are not sufficient, a clear agreement of how the employee shall behave and how one has brought things in order.

Aim and feedback results will be a target of the day-to-day manager/supervisor entering into a dialogue with his employees about safety and risks.

Step 7

The third step is to hold toolbox meetings with a special focus on safety and risks. It could include tasks that may only be performed seldom or that contain special risks or tasks, where groups of people shall have their activities co-ordinated, when new employees shall be introduced to a task. Such toolbox meetings are comprised of a supervisor discussing the task through with the group of people that shall perform the task and going through what risks the task holds, who does what and when, how the communication shall be secured underway, what safety barriers that shall especially have an eye kept on and what each shall especially do if there is a failure in the safety barriers.

Toolbox meetings do not need to take a long time and should be carried out immediately before the work commences. But it requires a certain preparation, so one has the equipment that shall be used and the knowledge and competence that is needed.

Aim and feedback results are that this preparation occurs, that toolbox meetings are held and that employees have competencies to carry out and co-ordinate the job tasks.

Step 8

The fourth step is, that an ongoing form of internal audit occurs with focus on the safety level and maintenance of safety barriers. It is proven (Rasmussen 1997), that safety has the tendency to degenerate over time, when accidents don't occur for a period and one, therefore, sees that everything is in order. It is also through an audit that one can observe the fulfilment of goals from the results of the other steps so that after an internal review, feedback can occur to management as well as employees. One can carry out an internal audit in different ways both with internal or external resources. It is essential that everyone is clear over it occurring, what is observed and when and that everyone knows about the results.

Aim and feedback of the audit is that it is carried out and that feedback is given on the results from the audit.

6.3.4 Symbolic process of the programme

The aim of this process is to create motivation, pride and happiness over achieving the goals that the change process has set for itself. It is through this that a new identity is created and hopefully also an acceptance of a new cultural level in the safety area.

The project proposes 2 steps (Steps 9-10), which can be developed into many separate steps.

Step 9

The first step is to secure management's visibility and trust in the entire change process. This can e.g. occur by him regularly carrying out "walk-arounds", where he shows his interest and priority for tasks and the safety that is associated with this. Generally, it is important that the manager always adheres to the guidelines himself, which are developed for the employees, and that the manager never goes past a workplace where a safety barrier is not in order without taking action. On the other hand it is just as important that the manager in his walk-around expresses praise and recognition to the employees who perform their work in a safe manner.

Management's visibility and trust also comes to an expression through resource allocation when there are desires for a safety condition, just as a reaction occurs when there is a violation. This should apply in communication and co-ordination from management toward both employees and middle management. Similarly, it should apply when management reward in the form of giving greater responsibility, better salaries, new tasks, etc.

Step10

The second step is to develop and create symbols, stories, events, etc., which give colouring to everyday, create fellowship and social identity. It is these arrangements that hold both management's and employee attention, because it is here an expectation is created and a joy when the goals are attained and rewarded. There can be talk of many different activities, which fundamentally shall be of a type that employees value. Examples of such activities are:

- Social events, both small and large, cakes on Fridays, parties, dinners, etc.
- The good stories in a newsletter or simply on a notice board with praise and recognition.
- Prizes awarded for good initiatives and good execution.
- A symbol of recognition visibly placed in the departments that have earned it.
- Honour and credit to the frontrunners

It is important that ongoing information occurs about the results, initiative, prioritisations, changes, rewards that means everyone has an understanding that something is happening and that notice is being paid to how it is going.

6.4 APV and Injury Risk Audit

The concepts for an APV and an Audit for accident risks should necessarily be based upon an evaluation of hazards and associated safety barriers: The other is an evaluation of the activities that are implemented to ensure that there is an ongoing control of the risk conditions, maintenance of the safety barriers and adherence to risk consciousness.

6.4.1 APV concept for injury risk

An APV concept for injury risk should take a point of departure in the 4-17-64 hazards, i.e. diagram 22. One can start with the 4 main areas and specify which of the 17 risk areas that are relevant to go further with. In this way one can limit the scope of risk, which shall be observed on the more specific 64 level. First, the following main areas are taken each on its own:

- A. The foundation where it is walked or worked
- B. The surroundings where it is walked or worked
- C. What is worked with or by
- D. Surroundings of a particularly dangerous nature.

For each main area, focus is placed on sub-areas, such as e.g. Point A whether there is risk for fall to a lower level, or falls to the same level.

If there is a risk of fall to a lower level an evaluation can be carried out with the aid of the INFOcard. But if there is talk of one of more specific types of risks, one can look at them by first pointing out them in the list of hazards and then checking the safety barriers and quality parameters in the Dutch materials.

Falls from heights – movable ladder
Falls from heights – fixed ladder
Falls from heights – stepladders
Falls from heights – rope ladders
Falls from heights – mobile scaffolding
Falls from heights – fixed scaffolding
Falls from heights – erection/dismantling of scaffolding
Falls from heights – roofs
Falls from heights – areas, floors with large differences in level
Falls from heights – fixed platforms
Falls from heights into holes (e.g. in the earth, floors)
Falls from heights – mobile platforms
Falls from heights – stationary vehicles
Falls from heights – other work at height without protection

By taking the hazards step by step in this systematic manner, one has the possibility to have carried out a risk assessment for accidents.

It presupposes that the APV concept is carried out for each individual job and task as the risk varies with which task is carried out, where it is carried out, how it is carried out and under what conditions they are performed. It is therefore appropriate to involve the individual employee in the identification of hazards in the concrete tasks and at the same time have a dialogue about which hazards are present and what safety barriers are in use, as well as in what way the safety barriers are guaranteed used and maintained. Here can either the INFOcards in Appendix A be put into use or

the more detailed information from the Dutch materials depending on which level of risk specification one is on.

With regard to the evaluation of accident risks it is important to be aware of tasks that are seldom performed but where the risk is great and perhaps where not much observance is attached with regard to method and safety, but where very little needs to go wrong before an accident occurs. An APV for accident risks shall especially seek to identify such tasks. Contrary to other working environment influence, the accident risk is a factor that simply needs to be high rather briefly, on order for an accident to occur with the resulting personal injury.

The APV concept must also evaluate the activities that are started in order to ensure a high risk consciousness in managers as well as employees. Under here, if one has carried out processes that create learning, responsibility and motivation to maintain a constant high level of safety. Herein lies an evaluation of the activities, their implementation and achievement of goals. Some of the indicators that can be included in an evaluation can be the following:

On top manager level:

Marker for “Good” behaviour	Marker for “Bad” behaviour
Understand the need for evaluation of accident risks and what the safety barriers are.	Do not feel the need for evaluation of accident risks and do not know what safety barriers are.
Understand what the threat is against maintaining good safety barriers and what there is a need for in the company.	Feels there is not a threat against maintaining good safety barriers and does not feel there is a need for it in the company.
Understand what is needed to get employees to be risk conscious.	Feels that it is the employee’s own problem to be risk conscious.
Understands the need for management being obliged to create a high safety level in the company.	Does not think that management can do more to increase the safety level in the company.
Understands the need for a learning process.	Does not think there is a need for a learning process.
Understands the need for a political process and clear distribution of responsibility.	Does not think there is a need for a political process and special placement of responsibility for safety.
Understands the need for a symbolic process and own role.	Does not feel there is a need for a symbolic process and does not have any own role.
Is willing to prioritise having a good safety culture created.	Does not feel there are grounds to prioritise a change in the safety culture.
Is willing to support the process with resources and energy.	Does not feel there is money or grounds to support a process with resources and energy.

On a middle management level/the small employer:

Marker for “Good” behaviour	Marker for “Bad” behaviour
Understand the need for evaluation of accident risks and	Do not feel the need for evaluation of accident risks and do

what the safety barriers are.	not know what safety barriers are.
Understand what the threat is against maintaining good safety barriers and what there is a need for in the company.	Feels there is not a threat against maintaining good safety barriers and does not feel there is a need for it in the company.
Understand what is needed to get employees to be risk conscious	Feels that it is the employee's own problem to be risk conscious.
Understands the need for the middle manager contributing to create a change with regard to risk consciousness in his/her own division.	Does not believe that the middle manager shall contribute to creating a change with regard to risk consciousness in his/her own division.
Understands the middle manager's responsibility and task in the learning process.	Does not feel that the middle manager has a responsibility and task in a learning process.
Understands the middle manager's responsibility and task in the political process.	Does not feel that the middle manager has a responsibility and task in a political process.
Understands the middle manager's responsibility and task in the political symbolic process.	Does not feel that the middle manager has a responsibility and task in a symbolic process.
Is willing to prioritise in order to have a good safety culture created in his/her own division.	Does not feel there is the need for prioritising to change on safety culture created in his/her own division.
Is willing to support the process with resources and energy.	Does not feel there is the need for using special resources and energy on safety.

Employee level:

Marker for "Good" behaviour	Marker for "Bad" behaviour
Understands what risks his/her job involves.	Does not have insight into what risks his/her job involves.
Understands what safety barriers must be in order in the tasks he/she performs.	Is not familiar with what safety barriers must be in order in the tasks he/she performs.
Understands what risk consciousness he/she shall be in receipt of while performing the tasks.	Does not have appreciable risk consciousness in relation to the tasks that he/she shall perform.
Is positive toward participating in a change process, where he/she can develop his/herself further.	Does not feel there is the need for changing anything.
Is positive toward participating in a learning process.	Does not feel there is a need for any form of learning process.
Is positive toward participating in a political process.	Does not feel there is a need for a political process with particular responsible tasks.
Is positive toward working in a symbolic process.	Feels a symbolic process is unimportant.
Is willing to contribute to increase the safety culture.	Does not feel there is any ground to increase the safety culture.
Is prepared to make his contribution with own resources and energy on safety.	Does not wish to contribute own resources and energy on safety.

6.4.2 Audit concept in the area of injury

An audit programme does not differ significantly in its content from the APV concept, as it contains an overview of the concrete hazards and their safety barriers, as well as an overview of initiatives that are taken or lack being taken to create a high level of safety and a good safety culture.

An audit of the concrete hazards and their safety barriers should be based on what one can see and that one can ask about within a reasonable amount of time. That is to say, that it will not be possible to go through all tasks together with the employees that are described in an APV survey. But one can still go through unit by unit and look for hazards and safety barriers in the same way as stated under APV, namely by looking first at the 4 main areas, then the sub-areas and in each place check whether the safety barriers are in place, maintained, controlled and whether the quality parameters are filled.

The INFO cards in Appendix A and the specific lists safety barriers and PIE's are the basis for this check.

It is also important that in an audit it is asked about the rare, but particularly risk filled tasks and what safety barriers are established in association with the performance of these tasks.

An Audit going through of the implementation of initiatives and changes in order to achieve a high risk consciousness and a good safety culture can include the following:

Identification of deficiencies in the learning process

Marker for "Good" behaviour	Marker for "Bad" behaviour
A training programme about risk consciousness and safety barriers is worked out for all in the management team.	There is not a training programme about risk consciousness and safety barriers for the management.
There is a training programme about risk consciousness and safety barriers for all supervisors.	There is not a training programme about risk consciousness and safety barriers for the supervisors.
There is a training programme about risk consciousness and safety barriers for all supervisors.	There is not a training programme about risk consciousness and safety barriers for the employees.
There is a special training programme about risk consciousness and safety barriers for all new employees and especially for young employees.	There is not a training programme about risk consciousness and safety barriers for new employees or the young.
There is a special programme for external players, which for a shorter or longer time will work at the company.	There is not a special programme for external players, that for a shorter or longer time will work at the company.
That a thorough APV investigation about the presence of risks and safety barriers in the company has been carried out, which can be included in this training.	That a thorough APV investigation about the presence of risks and safety barriers has not been carried out in the company.
That "On the job" training has been carried out in a co-operation between supervisor and employees.	That "On the job" training has not been carried out in a co-operation between supervisor and employees.
That all employees have been made aware of what risks they shall be aware of, what safety barriers they shall observe if they are in order and what expectations there are to their actions on this.	That none of the employees have been made aware of what risks they shall be aware of, what safety barriers they shall observe if they are in order and what expectations there are to their actions on this.
That all important information about risks and safety barriers is made easily accessible and understandable for	That no information about risks and safety barriers are

employees.	made available or understandable for employees.
That all employees know where they can find this information and know how they shall use it.	That no employees know where they can find this information or know how they shall use it.
That all employees know how they shall report accidents and near accidents and that they are motivated to do it.	That no employees know how they shall report accidents and near accidents and no-one is motivated to do it.
That all reported events are analysed and the results are reported, and that actions are taken to secure against repeats.	That no analysis of any events is made and there is no form of action to guarantee against repeats.

Identification of deficiencies in the political process

Marker for “Good” behaviour	Marker for “Bad” behaviour
That management understands their responsibility for the change process and what they shall do to increase the risk consciousness and ensure the safety barriers.	That management does not intend to carry out a change process and they do not understand what they shall do to increase the risk consciousness and ensure the safety barriers.
That supervisors understand their responsibility and what they shall do to increase the risk consciousness and to insure the safety barriers.	That supervisors do not know their responsibility or what they shall do to increase the risk consciousness and to insure the safety barriers.
That a daily dialogue occurs between day-to-day managers/supervisors and employees about the risks and safety barriers.	That there is not form of daily dialogue between day-to-day managers/supervisors and employees about the risks and safety barriers.
That supervisors carry out toolbox meetings, especially when new tasks shall be started or special tasks shall be performed.	That supervisors do not carry out toolbox meetings.
That employees are always involved when new plans are made new initiatives are launched, new equipment is purchased, etc.	That employees are never involved when new plans are made, new initiatives are launched, and new equipment is purchased, etc.
That employees actually participate and know how they can make their influence valid.	That employees never participate or know how they can make their influence valid.
That employees can tell about how their supervisor contributes to making aware of risks and checks safety barriers.	That employees can tell that their supervisor never makes them aware of risks and checks the safety barriers.
That employees can tell about how their supervisor conducts toolbox meetings and involves risk consciousness and the evaluation of safety barriers in these meetings.	That employees can tell that their supervisor never conducts toolbox meetings and involves risk consciousness and evaluation of safety barriers.
That regular internal audits for safety barriers and risk consciousness are carried out.	That internal audits are never carried out for safety barriers and risk consciousness.
That there is a feedback system for audit results and that they are communicated out to the employees.	That no form of feedback is given for any audit results.

Identification of deficiencies in the symbolic process

Marker for “Good” behaviour	Marker for “Bad” behaviour
That management has informed about goals for a changed risk consciousness and quality assurance of the safety barriers.	That management has not set any goal for a changed risk consciousness and quality assurance of the safety barriers.
That management has informed about the goals being achieved and how ongoing feedback will occur for this.	That management does not have any information about how the safety could be improves or achieved.
That management understands how important it is that he/she is visible in relation to prioritisation of risk consciousness and quality assurance of the safety barriers.	That management doe not feel there are any grounds to prioritise risk consciousness and quality assurance of the safety barriers.
That management regularly carries out “walk-arounds” and speaks with both middle management and employees about risks and safety.	That management never carries out “walk-arounds” and speaks with both middle management and employees about risks and safety.
That management itself always follow the procedures for safety barriers, which he wants the employees to follow and that he observes the safety barriers that contain deficiencies, and acts on them straight away so that they can be corrected.	That management itself does not always follow the procedures for safety barriers, which he wants the employees to follow and that he does not observe the safety barriers, that contain faults.
That management primarily has focus on the positive results for risk consciousness and qualitative safety barriers and that recognition occurs to those who participate in achieving the good results.	That management only focuses on the negative results for a lack of shown risk consciousness and defective safety barriers.
That special events are organised when intermediate aims are achieved or when there is reason for celebrating such a particular success.	That no special events ever occur that have to do with safety and risk consciousness.
That both middle management and employees are rewarded for good results in the safety field.	That no form of reward occurs for those who have shown risk consciousness.
That there is a history telling in the company about the good results and an identity and pride over working in a place with good safety.	That the histories told in the company are about accidents and how lucky or unlucky one can be in near accidents.

6.5 Safety in SME

The conclusion in chapter 3 is that the small businesses have the need for methods and materials, which are easy to understand and that they can use with few resources. One of the characteristics if the small company’s management is that they generally view safety as something the individual employee has an own responsibility for, simply by the manager ensuring that the necessary equipment is available. This understanding must necessarily be changed to an understanding of what the manager can do daily in order to build up a good safety culture in the company, so that the employees take their part of the responsibility for safety.

The INFO cards are precisely created to fulfil this need. However, it cannot be sufficient enough to simply hand over such INFO cards, without placing their use in a frame. In that way the little company separates itself from the big company. In many ways the little company must go through

the same process as the large. The difference lies, on the other hand, in the formalisation and communication paths.

The need for creating a consciousness at the employer in the little company corresponds completely to the need in the large company. However, it can be more difficult in the little company, where it can be a long time between accidents, and where the managerial competencies are perhaps too limited to understand the opportunities and need to influence the safety. Precisely because accidents occur so seldom in the small company, the motivation and consciousness need to come from another place.

Demands from larger companies, from the insurance company or from an authority are central, but a network of companies that communicate about development and supplementary training or the like are a good supplement. In many ways, the first link in the chain of having created a higher safety consciousness is the most difficult.

As research shows (Hasle et al 2004), the road from decision and action is short in the small businesses. That is to say, that when the employer first has realised what he/she shall and wants, it doesn't take long until it is done.

Yet, he must still go through change management's 3 process steps and an ongoing aim and feedback management. But it can be made significantly less formalised in the small business. For example, training can be done with a short teaching course, where an external teacher comes to visit and introduces an understanding of the most relevant risks and safety barriers. "On the job" training and the continuous dialogue can occur daily, where the tasks are assigned. Small toolbox meetings with groups of employees can be carried out ad hoc, when the work gives rise to it. The employer can carry out ad hoc "walk-arounds" at the same time as he inspects the tasks that are performed. The employer can therefore carry out many of the process steps that a change process requires both informally and integrated. The important thing is, however, that the employer understands his role and has the necessary competence to carry out the process.

It will naturally be an aid to the employer in the small business that he shall not start from the bottom in relationship to train and practice a risk consciousness in his employees. Therefore it will be a good help to have an understanding of risks and safety barriers introduced as necessary competencies, which can be acquired through the educational systems.

It is important that especially young people are trained in such good competencies with regard to understanding risks as possible. It is also important that particular attention is paid to young people's education about the risks at work, as this is not something young people are automatically familiar with or in a position to realise. It is something that shall be learned, trained and order to be respected.

6.6 Need for further development

The development process in the DanWorm project has led to a number of tools for accident prevention and an understanding for ways that these tools can be put into use.

However, there are still a number of wishes for a continued process with that, which is lacking. Mentioned here are 3 areas where we can immediately see a developmental need. This applies to the following:

1. To have the change concept tested in a number of companies and have a result documented.
2. To have the perspective on safety barriers further developed and build it into the INFO cards.

3. To have the ORCA calculation tested in Danish conditions and to develop a set of Danish data.

6.6.1 Testing the change concept in the area of safety

The concept that is presented in this chapter 7 is developed on the basis of the theory basis from chapter 3 and the results from chapter 6. But the concept has not been tested in the real world. A new step could therefore be to carry out a regular intervention in a number of companies to investigate how the concept functions and what it requires to achieve a desired effect.

The intervention will involve a motivation of the management a demonstration of a need to have the risk consciousness increased, and raise the quality of the safety barriers. In that way an entire course of the change process is carried out and an evaluation of the effects that are achieved, which can be placed in relation to time and resource consumption.

Parallel to this, interventions should be carried out in special small businesses in order to illustrate, how a change process can be carried out and increase the risk consciousness, as well as which potentials that could be aimed at in a campaign for small businesses.

6.6.2 Development of INFO card and the perspective of safety barriers

In the DanWorm project INFO cards are drafted for the 17 groups of hazards, where the content involves a certain generalisation and therefore can lack the more detailed instructions.

A further development should therefore include the test of the existing INFO cards and draft INFO cards for all the 64 hazards. It will also be a goal to have a concept developed, after which companies can draft their own INFO cards targeted toward concrete hazards or activities.

In this connection it will also be appropriate to work further with the safety barrier concept itself and have it fully extended to the understanding that is expressed in figure 10.

Furthermore, it is important to arrange this way of looking at accident risk assessment and create an understanding for:

- safety barriers being in order, so that one can avoid accidents
- that safety barriers shall be in order even if no accidents have occurred in a long time
- that risk consciousness is a necessity in all forms of work
- that it is a managerial responsibility to have created and improved the risk consciousness in employees

6.6.3 Testing ORCA and establishment of a Danish data basis

The third development area is to have the calculation program ORCA used and test in what situations and contexts it can be put into use with a good result. The testing of the PDA program and transfer of data to ORCA and usage of the calculations are important development areas.

But it is naturally not usable in all forms of risk assessment. The requirements for the input that the calculations shall be performed on must be highlighted further. Partly so they can be minimised the most possible, but also so the calculations become as realistic and correct as possible to the situations they shall state the risk for.

An additional development of the software in ORCA can be appropriate in order to increase in relation to user friendliness and thereby create a larger use of the system.

There are also parts of the ORCA content itself that should be developed further. This applies, among others to:

- The basis that the recommendations to minimise the risk with are based on.
- The risks that are not included in ORCA, such as e.g. the traffic risk and expansion of the risk of different types of technical equipment.
- The question is whether the Danish conditions can be covered by the Dutch data,
- The possibilities for establishing Danish data that can counterbalance any differences.

6.7 Summary

There is no easy path to create a prevention of accidents, and there is no universal model that can be recommended as the way of making work in a company safe. In the Dutch Worm project and in the Danish DanWorm project a number of tools have been developed that can be used to evaluate the risk, predict dangers and perform preventive actions. But none of these tools will solitarily be able to prevent injuries.

Safety and a good safety culture are something one creates, and that shall be held onto in an ongoing and constant process. One will never be able to remove all dangers, but one can reduce the likelihood of accidents occurring by ensuring that the safety barriers are in place and function according to purpose.

Chapter 2 shows that safety is a management task, and an improvement of safety can be achieved, for example, through an aim-feedback system set into a change management concept. These management concepts are placed into use, as an illustration of, how the developed tools from chapter 5 can be used in a company.

One or more of the tools are taken into use both in a learning process, in a political process and in a symbolic process. Also shown is how one can in an APV as well as in an Audit can evaluate the safety level by using the knowledge of hazards and their safety barriers together with the function of the managerial level processes that shall ensure that the knowledge is used.

A small company shall, in principle, go through the same course and processes as larger businesses shall, but they can carry out the processes significantly more informally because their communication paths are simpler. On the other side, it will be more difficult to get the small companies to realise that they should work with safety in a systematic manner. This question is not solved in this project.

It is recommended to have the change concept tested in a safety field, so experiences can be harvested from the use of the tools in a managerial process. There will also be the need to have further developed the INFO cards for the specific 64 hazards and perhaps even on certain types of activities. There will also be the need to test the Dutch material behind the risk calculation and look at the need for an adaptation to Danish data and Danish conditions.

It is the hope that the project has given a contribution to an understanding of what the prevention of accidents requires and the tools and processes that are necessary for one to achieve a higher safety level in the work places.

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Appendix A

INFO cards

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A 1 INFO CARD for Falls from heights

In the WORM project, risk types that are associated with this risk factor are described through 12 different types of situations, where the risk for falls from heights occurs. This includes, for instance, stays on:

1. moveable ladders
2. fixed ladders,
3. step ladders,
4. rope ladders,
5. mobile scaffolding,
6. fixed scaffolding,
7. putting up/taking down scaffolding,
8. roofs,
9. surfaces with a difference in level,
10. fixed platform,
11. mobile platform,
12. vehicles, which stand still.

These 12 different risk types have different types of requirements and safety barriers, which among others, there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 4 generic safety barriers, namely questions of:

1. The equipment's strength
2. Railings, etc.
3. The equipment's placement and basis
4. User stability

The equipment's strength is about the carrying capacity in relation to the actual load, if it is maintained, cleaned and if it is used correctly, e.g. if the ladder's steps are in good condition and can bear the weight of a man and materials, or if the roof's carrying capacity can handle the weight of the persons who are on it.

Railings or other protection against falls is about special safety equipment, which shall ensure, they do not fall from heights if they should step wrong, stumble, or lose their balance for some other reason.

The equipment's placement and basis is about a person having chosen the correct equipment and that it is used properly. For ladders, this applies to e.g. the ladder's slope and securing, for scaffolding, this applies to the support and securing.

User stability is about behaviour, as well as physical and mental condition in relation to what is required for working at heights. It is about how a person stands, walks and works at heights with or without tools, and how a person handles materials.

MANAGEMENT			
Hazard: Fall from heights Includes stays at and work on all forms of ladders, scaffolding, platforms, differences in level, roofs, etc.			
Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
The equipment's strength	Observe whether the equipment is in order, cleaned and maintained. Investigate what equipment is needed for the tasks and its carrying capacity. Investigate whether there is a need for other equipment for the tasks. Observe whether employees give feedback when the equipment is not in order. Observe employee behaviour and use of the equipment.	Evaluate whether the carrying capacity and construction are appropriate to the task. Evaluate the maintenance condition. Evaluate the need for remedial measures. Evaluate the need for information to employees. Evaluate the need for special instruction. Evaluate the need for motivating initiatives for the employees.	Ensure faults are rectified and remove defective equipment. Inform employees about which equipment they must use and which equipment is defective or being repaired. Ensure there are procedures for the work and for cleaning and maintenance. Motivate and instruct employees about how they work at heights, and what feedback they must give when they find that things are not in order.
Railings	Observe the need for railings. Observe the railing quality. Observe whether railings are mounted correctly and in good maintained condition.	Evaluate accessibility, maintenance, strength and set-up of railings. Evaluate the motivation to ensure maintenance of the railing quality. Evaluate the need for special instruction. Evaluate the need for motivating initiatives for the employees.	Ensure that deficiencies are rectified. Inform employees about how they shall behave. Motivate and instruct employees about how you want them to behave when railings are lacking or are not in order.
The equipment's placement and basis	Observe the equipment's placement and basis. Observe the possibility that external circumstances can affect the equipment. Observe the need for special measures for protection. Observe employees ability to protect the equipment. Check approval of the equipment .	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance. Evaluate employees' ability and motivation to set up and use equipment correctly.	Ensure that deficiencies are rectified. Inform employees of the correct method and ensure that it is used. Instruct on setup, securing, foundation, placement, etc. Motivate employees to comply with procedures.
User stability	Observe employees' state of health before they are sent to heights. Observe the weather before the task starts up. Observe the employees' behaviour towards footwear, free hands	Evaluate whether employees are OK Evaluate whether employees can handle the task Evaluate whether employees know how their behaviour should be when working at heights Evaluate employees' motivation to exhibit safe behaviour	Ensure instructions/agreements are clear Ensure there is a good division of responsibility and tasks Create positive motivation to safe behaviour Ensure there is a consequent attitude for violations

EMPLOYEE			
Hazard: Fall from heights Includes stays at and work on all forms of ladders, scaffolding, platforms, differences in level, roofs, etc.			
Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
The equipment's strength	Observe whether the equipment is in order, cleaned and maintained. Investigate what equipment is needed for the tasks and its carrying capacity. Investigate whether there is a need for other equipment for the tasks.	Evaluate whether the carrying capacity and construction are appropriate to the task. Evaluate the maintenance condition. Evaluate the need for remedial measures.	Ensure that deficiencies are rectified. Ensure that the correct equipment comes into use. Remove defective equipment. Inform the employer and possibly colleagues, if the conditions are not in order. Follow the given instructions and procedures.
Need for railings	Observe the need for railings. Observe the quality and strength of the necessary railing. Observe whether the railing is mounted correctly and is in good maintained condition.	Evaluate accessibility, maintenance, strength and set-up of railings.	Ensure that deficiencies are rectified. Inform the employer and possibly colleagues, if there are deficiencies and what measures are necessary. Follow the given instructions and procedures.
The equipment's placement and basis	Observe the equipment's placement and basis. Observe the possibility that external circumstances can affect the equipment. Observe the need for special measures for protection. Check approval of the equipment .	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance.	Ensure that deficiencies are rectified. Inform the employer and possibly colleagues, if there are deficiencies and what measures are necessary. Follow the given instructions and procedures.
User stability	Observe your state of health before you work at heights. Observe the weather before the task starts up. Observe the need for particular behaviour, including footwear and free hands to hold on with.	Evaluate your own ability to work at heights. Evaluate whether you can handle the task Evaluate which behaviour is needed in the task for you and your colleagues' safety Evaluate methods of transport of materials and tools that shall be used for working at heights.	Know the necessary instructions/agreements. Know who has the responsibility and tasks. Ensure there are aids to lift up materials and equipment, so you have one hand free to be able to hold on. Carry out the task with safe and professional behaviour.

A 2 INFO CARD for Falls in the same level

In the WORM project, risk types that are associated with this risk factor are described through 2 different types of situations, where the risk for falls occurs. This includes, for instance, stays on:

1. Stays and activities in levels anywhere at all
2. Stays and activities on stairs

One can argue for, that stays and activities on stairs with the risk for falls, in just as high a degree, belong under falls at a lower level. The reason for bringing this risk condition under here is, partly that stays and activities in the same level and on stairs are very general risks that are often closely associated. Also, the safety barriers and PIE's are quite identical in these two risk types.

Furthermore, the 2 risk types have in common that they, on the one hand, are not perceived as being particularly risk filled because it is something we all do every day without something happening, and on the other hand, it is the risk condition that as an individual risk creates the basis for the most accidents.

In WORM analyses these risk types fundamentally contain 4 generic safety barriers, namely questions of:

1. The surface's condition and maintenance
2. The surface's slipperiness and cleaning
3. The presence of obstacles
4. User stability

The surface's condition and maintenance is about the presence of unevenness and clutter. For stairs, it is also about the stair construction, the kind of step, appropriate banisters, etc.

The surface's slipperiness is about cleaning, the presence of ice, snow, water, oil and the like.

The presence of obstacles is about access conditions, space to walk, and if there are leads and materials in the trafficked areas, etc.

User stability is about behaviour, as well as physical and mental condition in relation to what is required for the work. It is about how a person stands, walks and works with or without tools, and how a person handles materials. Does a person use the banisters when they walk the staircase? If a person runs, then there is a risk of falling. Is there enough light so that a person can walk? Is a person wearing the correct footwear for the task?

MANAGEMENT

Hazard: Falls in the same level

Includes stays and work in areas and stairs, etc.

Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
Surface's condition and maintenance	<p>Observe whether the areas and surfaces are in order, cleaned and maintained.</p> <p>Observe where there are holes, irregularities or other, which can cause falls. Including whether areas shall be walked on that involve a temporarily increased risk of fall.</p> <p>Observe the state of the stairs and whether there are many tasks with handling loads on stairs.</p>	<p>Evaluate whether there is a need for performing maintenance</p> <p>Evaluate whether there is the need for new cleaning procedures</p> <p>Evaluate the need for marking out e.g. holes and irregularities until they can be repaired</p> <p>Evaluate the need for special measures where it will be temporarily walked on</p> <p>Evaluate whether handing of loads on stairs can be avoided</p>	<p>Ensure that deficiencies are repaired</p> <p>Ensure that procedures for cleaning and maintenance are adhered to</p> <p>Ensure that the use of stairs is minimised when handling loads</p> <p>Motivate and instruct employees about how you want them to act when they walk, especially on stairs</p>
The surface's slipperiness and cleaning	<p>Observe the surface's slipperiness, including the presence of ice, snow, water, oil, grease, etc.</p> <p>Observe the level of cleanliness</p> <p>Observe whether there are procedures and instructions for actions, when situations occur where surfaces are slippery.</p>	<p>Evaluate whether surfaces are more slippery than they need to be.</p> <p>Evaluate whether situations can occur where surfaces can become slippery.</p> <p>Evaluate whether the cleaning level is in order.</p> <p>Evaluate whether there is a need for special procedures, when situations occur where surfaces become slippery</p>	<p>Ensure that deficiencies are rectified.</p> <p>Inform employees about how they shall behave.</p> <p>Motivate and instruct employees about how you want them to behave when situations occur with slippery surfaces or a lack of cleanliness.</p> <p>Correct the level of cleanliness and implement procedures for clearing e.g. snow and ice, spills on floors, etc.</p>
Presence of obstacles	<p>Observe areas where employees walk.</p> <p>Observe what obstacles for activities do not need to be there.</p> <p>Observe behaviour, which creates obstacles for the activities of others.</p>	<p>Evaluate whether the areas walked in can be changed, adapted so that it eases the general activities.</p> <p>Evaluate the need for procedures that ensure obstacles are not created for general activities.</p>	<p>Ensure that deficiencies are rectified.</p> <p>Ensure there is a procedure to avoid obstacles for activities.</p> <p>Instruct in avoiding obstacles for activities</p> <p>Motivate employees to comply with procedures.</p>
User stability	<p>Observe employees' state of health</p> <p>Observe behaviour and actions during activities, not least when handling loads.</p> <p>Observe whether there is sufficient lighting to see where one walks.</p> <p>Evaluate whether correct footwear is used</p>	<p>Evaluate whether there is a need changing the division of tasks and the tasks organisation.</p> <p>Evaluate whether there is a need for instruction</p> <p>Evaluate whether there is a need for better lighting</p> <p>Evaluate whether there is a need for special footwear</p>	<p>Ensure that employees who have health problems are assigned tasks that take this into regard.</p> <p>Inform and instruct employees about how you expect them to go about and otherwise perform the work.</p> <p>Inform about how the lighting shall be adapted and possibly about the use of correct footwear.</p>

EMPLOYEE

Hazard: Falls in the same level

Includes stays and work of all forms on areas and stairs, etc.

Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
Surface's condition and maintenance	<p>Observe whether the areas and surfaces are in order, cleaned and maintained.</p> <p>Observe where there are holes, unevenness or other that can cause falls.</p> <p>Observe the areas where you will walk, also including areas that temporarily involve an increased risk of falls.</p> <p>Observe the state of the stairs and whether you will handle loads when walking on the stairs.</p>	<p>Evaluate whether there is a need for maintenance.</p> <p>Evaluate whether there is a need for cleaning.</p> <p>Evaluate the need for marking out e.g. holes and irregularities until they can be repaired</p> <p>Evaluate whether there is a need for special measures, where you will walk temporarily.</p> <p>Evaluate whether handing of loads on stairs can be avoided</p>	<p>Inform your employer of faults. Rectify those faults you can yourself.</p> <p>Keep the area where you work clean.</p> <p>Ensure that you minimise the use of stairs when handling loads.</p>
The surface's slipperiness and cleaning	<p>Observe the surface's slipperiness, including the presence of ice, snow, water, oil, grease, etc.</p> <p>Observe the level of cleanliness</p> <p>Observe whether there are procedures and instructions for situations where surfaces are or can become slippery.</p>	<p>Evaluate whether the surface is slippery.</p> <p>Evaluate whether sudden situations can occur where surfaces can become slippery.</p> <p>Evaluate whether the cleaning level is in order.</p> <p>Evaluate whether there are others who can take care of the problem or whether you need to take care of it yourself.</p>	<p>Inform your employer of faults. Rectify those faults you can yourself.</p> <p>Ensure you keep the area where you are working clean, remove ice, snow, water, spills.</p>
Presence of obstacles	<p>Observe areas where you walk.</p> <p>Observe which obstacles for walking that do not need to be there.</p> <p>Observe behaviour, which creates obstacles for the activities of others.</p>	<p>Evaluate whether the areas walked in can be changed, adapted so that it eases the general activities.</p> <p>Evaluate whether there are others who can take care of the problem or whether you need to take care of it yourself.</p>	<p>Inform your employer of faults. Rectify those faults you can yourself.</p> <p>Ensure you keep order and remove obstacles where you walk.</p>
User stability	<p>Observe your state of health</p> <p>Observe your own behaviour and actions during activities, not least when handling loads.</p> <p>Observe whether there is sufficient lighting, so you can see where you are walking.</p> <p>Observe whether you are using the correct footwear.</p>	<p>Evaluate whether you are fit for the task.</p> <p>Evaluate whether you need an aid e.g. for handling loads.</p> <p>Evaluate whether you have enough light to see where you are walking.</p> <p>Evaluate whether you need to use other footwear.</p>	<p>Inform your employer if you cannot manage the task.</p> <p>Retrieve those aids that are appropriate to the task.</p> <p>Rectify those faults you can yourself.</p> <p>Exercise safe behaviour where you walk.</p>

A 3 INFO CARD for Struck by objects, which can fall down

In the WORM project, risk types that are associated with this risk factor are described through 5 different types of situations, where the risk for falls occurs. This includes the risk for being struck by falling objects from:

1. Crane or lift
2. Other mechanical lifting situations
3. Means of transport of conveyor belt
4. Manual lifting
5. Storage of objects at heights

The 5 risk types have in common that they lift, handle or store objects, materials, etc. in a manner that involves the risk that these objects or materials can fall down and strike those who may be under them. That is to say, that it is about a combination of something falling down, at the same time as someone can be below where it may fall down.

In WORM analyses these risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. The equipment's placement and basis
2. Lifting method and storage method
3. Influence from external forces
4. Delimitation of the danger zone
5. The user's abilities and behaviour

The equipment's placement and basis is about whether the equipment is correct for the task with respect to capacity and carrying capacity, whether it is in a well-maintained state, whether it is complete in its construction and adheres to the applicable rules for design and function. It is also about the equipment's foundation, e.g. whether the crane or lifting equipment is supported correctly, if the storage shelves are supported appropriately.

Lifting method and storage methods are about the choice of lifting equipment and lifting methods, including the choice of manner of fastening, stability of the loads that are lifted, lifting speed, overload, etc., and about the choice of storage methods and stacking methods.

Influence from external forces is about the potential for external conditions can create instability of either the lifting equipment, storage equipment or of the loads that are lifted. It can, for example, be when driving or in heavy winds.

Delimitation of the danger zone is about access to the areas, where falling objects, materials can occur. This concerns, among others, all areas within which lifting over 2 metres high occurs, but it also applies e.g. to areas, where work occurs on a level at heights.

The user's ability and behaviour is about the ability to operate the equipment, the respect for the risk and danger zones, the use of safety helmet where it is required, the ability to handle loads manually and attention to the use of aids.

MANAGEMENT

Hazard: Struck by objects that can fall down

Includes all areas where lifting occurs using cranes, lifts and other mechanical lifting situations, lift with means of transport and conveyor belts, as well as with manual lifts and storage of objects at heights

Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
The equipment's placement and basis	Investigate whether the equipment's capacity and carrying ability is in order in relation to the task. Observe whether the equipment is complete, is quality assured and in a good maintained state. Observe whether the equipment has the correct foundation	Evaluate the task's possibilities for loading equipment. Evaluate the need for maintenance measures. Evaluate the need for special instructions. Evaluate the need for improvements for foundations, support.	Ensure that deficiencies are rectified. Ensure that procedures for cleaning and maintenance are adhered to. Ensure that load requirements, set-up requirements, foundation requirements are adhered to.
Lifting method and storage method	Investigate which lifting method is best suited to the task, including the manner of fastening. Investigate which storage methods are best suited for storage and stacking of concrete objects, when it occurs at heights.	Evaluate the variation of lift, loads, tasks, which shall be handled with the equipment that is chosen. Evaluate the variation of needs for goods to be stacked and their stability.	Ensure that deficiencies are rectified. Ensure that procedures for lifting, loads, methods, stacking, etc. are adhered to.
Influence from external forces	Observe the possibility of external influences, e.g. collision. Observe weather conditions, especially in heavy winds. Observe whether there are other conditions and collision opportunities associated with concrete lifting tasks.	Evaluate which safety provisions are necessary to set into work. Evaluate whether the task shall be put on hold temporarily. Evaluate the need for co-ordination with other tasks that can collide.	Ensure that deficiencies are rectified or necessary safety measures are carried out. Ensure that procedures in heavy winds are adhered to. Carry out co-ordinated agreements, where necessary.
Delimitation of the danger zone	Observe whether there is clear delimitation of danger zones with all lifting above 2 metres. Observe whether this delimitation is respected. Observe whether there are other tasks performed within the danger zone.	Evaluate which safety provisions are necessary to set into work. Evaluate the need for co-ordination with other tasks and people's activities within the danger zone.	Ensure that deficiencies are rectified or necessary safety measures are carried out. Carry out co-ordinated agreements, where necessary.
The user's abilities and behaviour	Observe employee competence for the task and in usage of the equipment. Observe whether safety equipment is used (helmet). Observe whether manual lifting occurs, where an aid could be used.	Evaluate the concrete task's requirements for competence and experience. Evaluate the need for instruction on the use of safety equipment and the use of aids.	Ensure that the correct competencies are in place. Implement guidelines for the use of safety equipment and aids. Motivate and instruct employees in how tasks are carried out and how you want them to behave.

EMPLOYEE			
Hazard: Struck by objects that can fall down Includes all areas where lifting occurs using cranes, lifts and other mechanical lifting situations, lift with means of transport and conveyor belts, as well as with manual lifts and storage of objects at heights			
Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
The equipment's placement and basis	Investigate whether the equipment's capacity and carrying ability is in order in relation to the task. Observe whether the equipment is complete, is quality assured and in a good maintained state. Observe whether the equipment has the correct foundation	Evaluate the task's possibilities for loading equipment. Evaluate the need for maintenance measures. Evaluate the use of special instructions Evaluate the need for improvements for foundations, support.	Ensure that deficiencies are reported to the employer and rectify what you can yourself. Ensure that procedures for cleaning and maintenance are adhered to Ensure that load requirements, set-up requirements, foundation requirements are adhered to.
Lifting method and storage method	Investigate which lifting method is best suited to the task, including the manner of fastening. Investigate whether the chosen storage methods are suited to the concrete object.	Evaluate whether the lift can be done with the equipment that is available, including the load's weight, shape, strength, lifting height, span, etc. Evaluate whether storage and stacking of objects is appropriate and stable.	Ensure that deficiencies are reported to the employer and rectify what you can yourself. Ensure that procedures for lifting, loads, methods, stacking, etc. are adhered to.
Influence from external forces	Observe the possibility of external influences, e.g. collision. Observe weather conditions, especially in heavy winds. Observe whether there are other conditions and collision opportunities associated with concrete lifting tasks.	Evaluate whether necessary safety measures are in place before you begin a lift. Evaluate whether the task shall be stopped temporarily until the conditions are in order. Evaluate the need for co-ordination with other tasks that can collide.	Ensure that safety related deficiencies and problems are reported to the employer and rectify what you can yourself. Ensure that procedures in heavy winds are adhered to. Carry out co-ordinated agreements, where necessary.
Delimitation of the danger zone	Observe whether there is clear delimitation of danger zones with all lifts above 2 metres. Observe whether this delimitation is respected. Observe whether there are other tasks performed within the danger zone.	Evaluate whether necessary safety measures are in place before you begin a lift. Evaluate whether the task shall be stopped temporarily until the conditions are in order. Evaluate the need for co-ordination with other tasks and people's activities within the danger zone.	Ensure that safety related deficiencies are reported to the employer and rectify what you can yourself. Carry out co-ordinated agreements, where necessary. Ensure that procedures are adhered to and agreements about activities and stays in the danger zone.
The user's abilities and behaviour	Investigate which competencies the use of equipment requires. Investigate the requirement about the use of safety equipment. Investigate the possibilities for the use of aids in tasks that require manual lifting.	Evaluate whether you possess the necessary competencies and experience. Evaluate your need for instruction and the procurement of aids.	Ensure that you receive the correct competencies and do not take on tasks where you lack these. Use the prescribed safety equipment. Use the aids that are available or that can be procured. Follow the assigned procedures

A 4 INFO CARD for Struck by flying object

In the WORM project, risk types that are associated with this risk factor are described through 2 different types of situations. This includes the risk for being struck by falling objects from:

1. Machines and hand tools
2. Products subjected to pressure or stress
3. Subjection to strong wind

Common to the 3 risk types is that they contain an influence of materials, objects, tools, etc., which has the consequence that either all or parts of what is machined can be flung out into an area where people are. Different technical machining forms, in addition to pressure or stress, are included in such influences.

In WORM analyses these 3 risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. Material's or product's state and attachment
2. The tool's or machine's state and function
3. Technical safety equipment
4. Delimitation of the danger zone
5. The user's abilities and behaviour

The material's and product's state and attachment is about whether there is a fault in the product and its strength, or if the product is not attached correctly or is subjected to an unsuitable pressure/stress, also if the product is handled appropriately, and whether it has become stuck in the equipment and thereby placed under pressure that was not intended, or if it is subjected to strong wind

The tool's or machine's state and function is about whether the correct equipment is used, whether the equipment is used for beyond what it is constructed for, whether the equipment is defective or functions incorrectly. This applies both to the equipment as a whole, as well as for individual parts.

Technical safety equipment is about the safeguarding of equipment that exerts pressure or stress, of safeguarding equipment that is not in use, of protection, which ensures that flying parts are captured where one knows they can occur, including emergency stop with error function or securing objects that can be subjected to strong winds.

Delimitation of danger zones is about access to areas where one knows that there are flying materials, which can be purely technical obstacles in access to safety zones, as procedures for who and where one may walk.

The user's behaviour and abilities is about ability and competence to operate equipment and handle products, but it is also about the respect for danger zones, and about the use of safety equipment, e.g. for eye protection, where it is necessary.

MANAGEMENT

Hazard: Being struck by flying objects

It includes areas, where there is a risk of being struck by flying objects from either machines or hand tools, from products subjected to pressure or stress or from objects in heavy winds

Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
Material's or product's state and attachment	Investigate the product's quality, state, strength and design. Investigate whether the products can be fastened incorrectly, become stuck or become subjected to incorrect pressure/stress. Investigate fastening in relation to subjection for heavy wind.	Evaluate whether action shall be taken toward products of poor quality. Evaluate whether technological changes shall occur to equipment or methods. Evaluate the need for procedures for handling risk situations, including heavy wind.	Ensure that deficiencies are rectified. Ensure that the quality of the products increases, and that a sorting out occurs before processing. Carry out the necessary technological changes. Establish the necessary procedures.
The tool's or machine's state and function	Investigate whether the tools and machine capacity and performance are in order in relation to the task. Observe tool and machine maintenance and cleaning Observe whether there are individual parts in tools or machines that need to be replaced or maintained	Evaluate the task's possibilities for overloading tools or machines. Evaluate the need for maintenance measures. Evaluate the need for special instructions.	Ensure that deficiencies are rectified. Ensure that procedures for cleaning and maintenance are adhered to Ensure that load requirements, usage requirements are adhered to.
Technical safety equipment	Observe whether the necessary safety equipment is in place, in order and in use, including fencing that can capture flying parts and emergency stop, which can stop tools and machines in the event of an error or when subjected to heavy winds.	Evaluate the need for additional technical safety equipment. Evaluate the need for maintenance of safety equipment. Evaluate the need for instruction in the use of safety equipment.	Ensure that defects are rectified or new equipment purchased/ developed. Ensure that procedures for cleaning and maintenance are adhered to Ensure that usage requirements are adhered to.
Delimitation of danger zones	Observe whether there is a clear delimitation of danger zones, where one knows that materials can fly out and that they are respected. Observe whether tasks are performed within the danger zone, which safety is not created for.	Evaluate whether there is a need for additional delimitation of safety zones. Evaluate the need for instruction in relation to respect for danger zones. Evaluate the need for tasks that are performed within danger zones and associated safety equipment.	Ensure that deficiencies are rectified or necessary safety measures are carried out. Start the work preparations that ensure danger zones can be respected.
The user's abilities and behaviour	Observe employee competence in relation to the task and in usage of the equipment. Observe whether safety equipment is used (eye protection).	Evaluate the concrete task's requirements for competence and experience. Evaluate the need for instruction on the use of safety equipment and the use of aids.	Ensure that the correct competencies are in place. Ensure there are guidelines for the use of safety equipment and aids. Motivate and instruct employees about how you want them to perform tasks.

EMPLOYEE

Hazard: Being struck by flying objects

It includes all areas, where there is a risk of being struck by flying objects from either machines or hand tools, from products subjected to pressure or stress or from objects in heavy winds

Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
Material's or product's state and attachment	Investigate the product quality, state, strength and design. Investigate whether the products can be become stuck, fastened incorrectly or become subjected to incorrect pressure/stress. Investigate fastening in relation to subjection for heavy wind.	Evaluate whether action shall be taken toward products of poor quality. Evaluate whether technological changes shall occur to equipment or methods. Evaluate the need for procedures for handling risk situations, including heavy wind.	Ensure that safety related defects and problems are reported to the employer and rectify what you can yourself. Ensure that bad products are sorted out for working on.
The tool's or machine's state and function	Check whether the tools and machine capacity and performance are in order in relation to the task. Observe tool and machine maintenance and cleaning Observe whether there are individual parts in tools or machines that need to be replaced or maintained	Evaluate the task's possibilities for overloading tools or machines. Evaluate the need for maintenance measures. Evaluate the need for special instructions.	Report safety related defects and problems to the employer and rectify what you can yourself. Adhere to procedures for cleaning and maintenance. Replace machine parts and tool parts when they are worn out. Observe requirements for loads and usage.
Technical safety equipment	Observe whether the necessary safety equipment is in place, in order and in use, including screening that can capture flying parts and emergency stop, which can stop tools and machines in the event of an error or when subjected to heavy winds.	Evaluate the need for additional technical safety equipment. Evaluate the need for maintenance of safety equipment.	Report safety related defects and problems to the employer and rectify what you can yourself. Adhere to procedures for cleaning and maintenance. Ensure that usage requirements are adhered to.
Delimitation of danger zones	Observe whether there is a clear delimitation of danger zones, where one knows that materials can fly out and whether they are respected. Observe whether tasks are performed within the danger zone, which there has not been safety created for.	Evaluate whether there is a need for additional delimitation of safety zones and your behaviour in relation to danger zones. Evaluate the tasks you shall perform within danger zones and the special safety-related measures it requires.	Ensure that safety related defects and problems are reported to the employer and rectify what you can yourself. Respect danger zones. Take the necessary safety-related measures.
The user's abilities and behaviour	Investigate which competencies the use of equipment requires. Investigate the requirement about the use of safety equipment. Investigate requirements for special safety-related behaviour.	Evaluate whether you possess the necessary competencies and experience. Evaluate your need for instruction and the procurement of aids.	Ensure that you receive the correct competencies and do not take on tasks where you lack these. Use the prescribed safety equipment and the aids that are available or that can be procured. Read the usage instructions and follow the assigned procedures.

A 5 INFO CARD for Struck by, colliding with or bumping into objects

In the WORM project, risk types that are associated with this risk factor are described through 7 different types of situations where the risk that people can be struck by, colliding with or bumping into objects occurs. It includes the risk of being struck by, colliding with or bumping into in the following situations:

1. Struck by means of transport
2. Stays and activities, where objects can roll or glide into people
3. Stays and activities in areas where others work with hand tools
4. Stays and activities in areas where others handle objects
5. Stays and activities near hanging and swinging objects
6. Stays and activities where there is the risk of becoming squeezed in between objects
7. Stays and activities that cause one to bump into objects, building parts, materials, etc.

The 7 risk types have in common that they contain a movement of either people or objects or both, which leads to one or another form of collision or squeezing together. It is the inappropriate movement of either the object in the people's surroundings or of the person himself it is about here.

In WORM analyses these 7 risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. Equipment's condition and functionality
2. Object's position and movement
3. Working method and execution
4. Delimitation of the danger zone
5. Overview and visibility
6. Technical safety equipment
7. The user's abilities and behaviour

The equipment's condition and functionality are about, partly whether it is in order, maintained and cleaned, partly whether it has the correct physical protection and control instruments, which mean that it doesn't come out of control and strike people, or that people do not strike themselves on it or become squeezed.

Equipment and product's position and movement is about storage or movement in relation to people's stays and activities. Here it is about avoiding collision due to either the equipment/product's placement and movement or people's placement and movement in relation to this.

Working method and execution is about activities in relation to the surroundings they shall take place in. Here, it is about space for the task and the opportunities to carry out the work, without collisions occurring. Delimitation of danger zones is about access to areas where equipment or products have a movement that is either controlled mechanically/electronically or by other people. It can, for example, be by transport, or where technical equipment moves around on objects or in another manner is in motion.

Overview and visibility is about the possibility for the individual person to be able to see and watch what is happening around him, and thereby give him the possibility to act appropriately.

Technical safety equipment is about the purely technical measures, which shall ensure that there is not anything that can roll, slide or in any other manner move itself unintentionally. It can be securing of machines, of products, of vehicles, of equipment, of building parts (doors), i.e. anything that can move itself in areas where people stay or walk, but where it is not the intent that it shall occur.

User's behaviour and abilities is about ability and competence to operate the equipment and handle the products, but it is also about respect for danger zones and attention to surrounding. It is also about ways, one goes about, where one stays and what behaviour a person exercises in relation to the surroundings a person is in.

MANAGEMENT			
Hazard: Struck by, colliding with or bumping into objects It includes all areas where there is a risk of being struck by a means of transport, rolling/sliding objects, other's hand tools, other's handling of objects, hanging/swinging objects, objects that can squeeze together, other due to own behaviour.			
Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
Equipment's state and functionality	Investigate the equipment's quality, state, maintenance and cleaning. Observe whether the equipment's physical safety is in order. Observe whether instruments, etc. function and are designed/placed appropriately.	Evaluate whether action shall be taken toward equipment that is not in order or is lacking maintenance and cleaning Evaluate whether the physical safety or equipment itself can be improved.	Ensure that deficiencies are rectified. Ensure that the quality of the equipment is increased. Carry out the necessary technological changes. Establish the necessary procedures.
Object's position and movement	Observe the equipment's and product's placement and movement in relation to people's stays and activities.	Evaluate whether the object shall be placed in another location. Evaluate whether people shall stay or be moved to other locations.	Ensure that deficiencies are rectified. Redo layouts, procedures, work arrangements so placements and movements or equipment/ products and people do not give rise to collision
Working methods and execution	Observe work arrangements of tasks in relation to where they shall occur. Observe whether there is appropriate space to perform the work in.	Evaluate the room and conditions under which different tasks are performed in relation to the risk of bumping into, colliding with, etc.	Ensure that deficiencies are rectified. Re-do layouts, procedures, work arrangements so placements and movements or equipment/ products and people do not give rise to collision
Delimitation of the danger zone	Observe the possibilities for collision between moving equipment/products and people and whether danger zones are identified and clearly marked.	Evaluate whether there is a need for additional marking of danger zones. Evaluate whether the danger zones are respected and whether there is a need for special instruction.	Ensure that deficiencies are rectified Start the work in a way that ensures danger zones can be respected.
Overview and visibility	Observe whether opportunities are created for an overview and visibility of moving parts, etc. for the people that are walking.	Evaluate whether there is a need for another layout of areas where people are and walk to ensure an appropriate overview and visibility in relation to smash-ups, collisions, etc.	Ensure that deficiencies are rectified. Implement the changes that shall ensure that employees have an overview and can see what happens.
Technical safety equipment	Observe whether the technical equipment is installed that shall ensure that equipment and products do not come in an inappropriate movement.	Evaluate the justification and need for increasing the technical safety. Evaluate the need for procedures in the use of technical safety equipment.	Ensure that deficiencies are rectified. Commence development/ purchasing of lacking technical safety equipment.
The user's abilities and behaviour	Observe employee competencies and motivation to stay or move in a safe manner in the surroundings that are made available.	Evaluate whether there is a need for stepping in over inappropriate behaviour. Evaluate the need for special instruction and motivation.	Make it clear to employees what safety-related behaviour you expect of them.

EMPLOYEE			
Hazard: Struck by, colliding with or bumping into objects It includes all areas where there is a risk of being struck by a means of transport, rolling/sliding objects, other's hand tools, other's handling of objects, hanging/swinging objects, objects that can squeeze together, other due to own behaviour.			
Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
Equipment's state and functionality	Examine the equipment's quality, state, maintenance and cleaning. Observe whether the equipment's physical safety is in order. Observe whether instruments, etc. function and are designed/placed appropriately.	Evaluate whether action shall be taken toward equipment that is not in order or is lacking maintenance and cleaning Evaluate whether the physical safety can be increased.	Report safety related defects and problems to the employer and rectify what you can yourself.
Object's position and movement	Observe the equipment and product placement and movement in relation to your activities.	Evaluate whether the object shall be placed in another location. Evaluate whether you shall stay or be moved to other locations.	Report safety related defects and problems to the employer and rectify what you can yourself.
Working methods and execution	Observe the work's organisation in relation to the surroundings. Observe whether there is space to perform the work in.	Evaluate the space and conditions under which your task is performed in relation to the risk of bumping into or colliding with,	Report safety related defects and problems to the employer and rectify what you can yourself.
Delimitation of the danger zone	Observe whether it is possible that you can collide between moving equipment/products/other tools Observe whether there are danger zones that are not identified and clearly marked	Evaluate whether there is a need for additional marking of safety zones. Evaluate your behaviour in relation to safety zones. Evaluate your stay and movements within the safety zone and the safety consideration it requires	Ensure that safety related defects and problems are reported to the employer and rectify what you can yourself.
Overview and visibility	Observe whether you have an overview and visibility over the surroundings you are in or walk in and whether you know what happens and where	Evaluate if you can see and monitor what happens around you and whether it requires particular attention from your side. Evaluate whether you can improve your overview and visibility	Ensure that safety related defects and problems are reported to the employer and rectify what you can yourself.
Technical safety equipment	Observe whether the technical equipment is installed that shall ensure that equipment and products do not come in an inappropriate movement.	Evaluate whether the technical equipment is proper and the need for increasing the technical safety. Evaluate the need for instruction in the use of technical safety equipment.	Report safety related defects and problems to the employer and rectify what you can yourself.
The user's abilities and behaviour	Investigate what competencies are required for being and walking in the area. Investigate requirements for special safety-related behaviour.	Evaluate whether you possess the necessary competencies and experience. Evaluate your need for instruction and the procurement of aids.	Ensure that you receive the correct competencies and do not take on tasks where you lack these. Use the prescribed safety equipment and the aids that are available or that can be procured. Follow the assigned procedures

A 6 INFO CARD for Being buried under loose material

In the WORM project, risk types that are associated with this risk factor are described through 1 different type of situation. This includes the risk for being buried under loose material when one works close to piled up materials, which can slip out or collapse.

This risk type includes all forms of piled up materials, which have the possibility to slip out or in another way bury the people who are nearby. This applies to bunkers of materials such as grit, sand, corn, shavings, plastic materials and similar materials, but also earth with excavations, waste and residual products that are accumulated, etc.

In WORM analyses this risk type fundamentally contains 5 generic safety barriers, namely questions of:

1. Material's inner stability
2. Material's outer protective capacity
3. Base's stability and capacity
4. Storage equipment's stability and function
5. User's abilities and behaviour

The material's inner stability is about e.g. the material bunker's angle of slope, presence of artificial protection or "learning walls", the presence of mixed materials, that changes occur in the bunker stability, when something is removed, the presence of wet materials and draining/drainage, stability in the manner of accumulation up, etc.

The material's outer protective capacity is about there being protection of the material bunkers or the accumulation against external influences such as e.g. collision, influence from the weather or similar.

The base's stability and capacity is about whether the base is strong enough, whether it can absorb vibrations and whether it can absorb water e.g. from rain and similar.

The storage equipment's stability and function is about e.g. the container's potential to become overfilled or broken fencing that can collapse from unilateral pressure and similar.

The user's ability and behaviour is about where one stays in relation to the piled up materials and whether a person has the knowledge and competence to realise that situations are about to occur that create instability in the piled up materials.

MANAGEMENT

Hazard: *to become buried*

This includes work nearby piled up materials that can slip out or fall together with the risk for being buried under loose material.

Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
Material's inner stability	Observe the material bunkers slope, mixture and moisture. Observe whether changes have occurred that have significance to the stability.	Evaluate whether there is instability in the piled up materials, or whether there is a condition that could create instability. Evaluate whether there is the need for new procedures or instructions when dealing with or working with such materials.	Ensure that deficiencies are rectified. Ensure that piled up materials are stabilised. Establish the necessary procedures.
The material's outer protective capacity	Observe whether there has been or can be a collision or influence from other forms of external forces (wind and weather) that can influence material stability.	Evaluate whether there is a need for new fencing, changing of transport and traffic roads, etc. Evaluate whether there is the need for new procedures or instructions when dealing with or working with such materials.	Ensure that deficiencies are rectified. Ensure that there is the necessary protection. Ensure that transport roads and traffic are adapted for placement of piled up materials. Establish the necessary procedures.
Base's stability and capacity	Observe the base's strength, skid-proofness, absorption, absorbency, etc. in relation to the materials the base shall support or bear.	Evaluate whether there is a need for changes of methods, including base for storage of materials. Evaluate whether there is the need for new procedures or instructions when dealing with or working with such materials.	Ensure that deficiencies are rectified. Ensure that the base is adapted to materials and conditions. Establish the necessary procedures.
Storage equipment's stability and function	Observe the containers, receptacles or fencing that shall contain the materials, if they are overfilled, if there is spill, if they are damaged beyond repair, if they can hold the quantity, etc.	Evaluate whether there is a need for maintaining receptacles, containers and fences. Evaluate whether there is sufficient capacity and that methods for filling, collection can occur without spill. Evaluate whether there is the need for new procedures or instructions when dealing with or working with such materials.	Ensure that deficiencies are rectified. Ensure that containers, receptacles, fences are maintained or replaced when they are damaged beyond repair. Establish the necessary procedures.
The user's abilities and behaviour	Observe whether materials are stored in areas where people are and walk. Observe whether people being or walking near piled up materials is appropriate.	Evaluate whether there is a need for stepping in over inappropriate behaviour. Evaluate the need for special instruction and motivation.	Motivate and instruct employees in how you want them to act regarding procedures and requirements, and how the tasks shall be performed.

EMPLOYEE

Hazard: to become buried This includes work nearby piled up materials that can slip out or fall together with the risk for being buried under loose material.			
Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
Material's inner stability	Observe the material bunkers slope, mixture and moisture. Observe whether changes have occurred that have significance to the stability.	Evaluate whether there is an instability in the piled up materials, or whether there is a condition that could create an instability.	Report safety related defects and problems to the employer and rectify what you can yourself. Do not stay near piled up materials that are unstable. Follow the assigned procedures
The material's outer protective capacity	Observe whether there has been or can be a collision or influence from other forms of external forces (wind and weather) that can influence material stability.	Evaluate whether there is a need for new fencing, changing of transport and traffic roads, etc.	Report safety related defects and problems to the employer and rectify what you can yourself. Do not stay near piled up materials that are unstable. Follow the assigned procedures
Base's stability and capacity	Observe the base's strength, skid proofness, absorption, absorbency, etc. in relation to the materials the base shall support or bear.	Evaluate whether there is a need for changes of methods, including base for storage of materials.	Report safety related defects and problems to the employer and rectify what you can yourself. Do not stay near piled up materials that are unstable. Follow the assigned procedures
Storage equipment's stability and function	Observe the containers, receptacles or fencing that shall contain the materials, if they are overfilled, if there is spill, if they are damaged beyond repair, if they can hold the quantity, etc.	Evaluate whether there is a need for maintaining receptacles, containers, fences. Evaluate whether there is sufficient capacity and that methods for filling, collection can occur without spill.	Ensure that safety related defects and problems are reported to the employer and rectify what you can yourself. Do not stay near piled up materials that are unstable. Follow the assigned procedures
The user's abilities and behaviour	Observe whether materials are stored in a manner that allows you to be or walk nearby in a safe manner Investigate what competencies are required for being and walking in the area. Investigate requirements for special safety-related behaviour.	Evaluate your safety by being or walking near the piled up materials. Evaluate whether you possess the necessary competencies and experience. Evaluate your need for instruction and the procurement of aids.	Do not stay near piled up materials that are unstable. Ensure that you receive the correct competencies and do not take on tasks where you lack these. Use the prescribed safety equipment. Use the aids that are available or that can be procured. Follow the assigned procedures

A 7 INFO CARD for Exposure to aggressiveness

In the WORM project, risk types that are associated with this risk factor are described through 2 different types of situations, where people can be exposed to aggressiveness. It includes the risk of being exposed to one or another form of violence from

1. Other people
2. Animals

The 2 risk types have in common that they contain a presence of either people or animals that have or can have an aggressive behaviour. In both cases it is about provocations, misunderstandings, tense situations, stress situations, a lack of physical distinction, the possibility to get help, self-defence, etc. But, there are also a number of differences where interaction with people, as a rule, is about communication and mutual relationships, while interaction with animals is about people's understanding for animal behaviour.

In WORM analyses these 2 risk types fundamentally contain 8 generic safety barriers, namely questions of:

1. Presence of aggressive people or animals
2. Safeguarding against provocations
3. Stressful situations
4. Prevention of aggressiveness
5. Physical separation
6. Breaking contact
7. Respect for danger zone
8. User ability and behaviour

Presence of aggressive people or animals, which without provocation are aggressive, is in the case of people e.g. about sick people and in the case of animals it is about dangerous animals found in the wild or that have escaped captivity.

Safeguarding against provocations between people is about avoiding arguments, misunderstandings in communication, verbal abuse, assault or excessive teasing. In relation to animals it is about the same conditions, where it solely is about people's provocation of the animal and not the reverse.

Stressful situations is about tense surroundings or situations, sudden changes in surroundings, wrong surroundings or the treatment of patients, criminal provocations, work with problematic people.

Prevention of aggressiveness is about the possibility to predict aggressive action and thus have the possibility to step in and change the situation so that it does not develop.

Physical separation is about separating people from either special groups of persons that one knows can have aggressive behaviour, e.g. criminal, certain patient groups, persons with financial debts, etc. Physical separation in relation to animals is about separating dangerous animals from people or "inexperienced people" from animals, this includes keeping animals on e.g. leashes.

Breaking of contact is about the possibilities for alarming and on call assistance, the possibilities for flight or the possibilities for self-defence.

Respect for danger zones is primarily about the relationship between people and animals, where people must understand animals reactions, especially toward strangers, e.g. dogs in other people's homes, wasps, horses that ride past and similar.

User's ability and behaviour in relation to people is about the ability to bypass other people, the ability to handle provocations. In relation to animals it is about the ability to work with animals, such as riding, tending to cows, keeping control of a dog, etc. but also whether one has experience and permission to deal with the relevant animal.

MANAGEMENT

Hazard: exposure to aggressiveness This includes all situations where there is a risk that people can be exposed to aggressiveness and violence from either other people or from animals			
Barrier types	Observe/investigate	Understand/interpret and evaluate	Act/perform
Presence of aggressive people or animals	Investigate whether employees can come in contact with aggressive people or animals.	Evaluate who there can be talk of and what measures should be implemented.	Ensure that deficiencies are rectified. Establish the necessary procedures.
Safeguarding against provocations	Examine the physical working environment and the employee's behaviour in relation to other people and toward animals.	Evaluate where there are problems and who there can be talk of and what measures should be implemented.	Implement change measures that can improve the physical working environment. Establish the necessary procedures.
Stressful situations	Investigate the physical working environment and what situations seem particularly stressful	Evaluate where there are problems and what measures should be implemented in order to minimise stressful situations	Implement measures that can minimise stressful situations. Establish the necessary procedures.
Prevention of aggressive-ness	Investigate who can be subjected to aggressive persons or animals	Evaluate what competencies these employees have use for so that they can anticipate and react	Ensure that these employees receive the necessary competencies to anticipate and react toward potentially aggressive persons or animals
Physical separation	Investigate the need and potential for a physical separation between employees and potentially aggressive persons or animals, they have or can come into contact with.	Evaluate the need and possibilities, and in what situations and circumstances there can be talk of creating a physical separation.	Implement change measures that can ensure a physical separation between employees and potentially aggressive persons or animals. Establish the necessary procedures.
Breaking contact	Investigate whether there is the need and possibility for ensuring alarming, on call assistance and self-defence for those employees who can come in contact with potentially aggressive persons or animals.	Evaluate the need and possibilities, and in what situations and circumstances there can be talk of using an alarm, on call assistance and self-defence.	Implement change measures that can ensure that there is an alarm, help can be called for and self-defence offered. Establish the necessary procedures.
Respect for danger zone	Investigate whether employees understand where the danger zones is in relation to strange or dangerous animals they can come in contact with.	Evaluate whether there is a need for efforts toward other people's securing of their animals when strangers (employees) come close. Evaluate whether there is a need for special instruction and procedures for employees behaviour.	Implement change measures that can secure those places employees come near strange or dangerous animals. Ensure safety is created surrounding these animals. Establish the necessary procedures.
The user's abilities and behaviour	Observe employee behaviour and ability to mix with other people and animals, especially including handling animals that are used in work.	Evaluate the need for special education and training, as well as special procedures for employee behaviour.	Implement the necessary education and training. Establish the necessary procedures. Motivate and instruct employees about how you want them to behave.

EMPLOYEE

Hazard: subjection to aggressiveness

This includes all situations where there is a risk that people can be exposed to aggressiveness and violence from either other people or from animals

Barrier types	Observe/ investigate	Understand/interpret evaluate	Act/perform
Presence of aggressive people or animals	Investigate whether there is a possibility that you can come into contact with aggressive people or animals.	Evaluate what situations there can be talk of and what measures you should implement.	Inform your employer of the situation and take your measures.
Safeguarding against provocations	Observe whether provoking behaviour occurs in your surroundings, such as arguments, excessive teasing, assault, etc.	Evaluate what situations there can be talk of and what measures you should implement.	Inform your employer of the situation and take your measures.
Stressful situations	Observe the situations you feel are stressful for you.	Evaluate which situations there can be talk of and how you can tackle them without becoming stressed.	Inform your employer of the situation and take your measures. Learn to tackle stressful situations
Prevention of aggressiveness	Investigate whether you can enter into situations where you can be subjected to aggressive persons or animals	Evaluate what competencies you have use for so that you can anticipate and react	Ensure that you receive the necessary competencies to anticipate and react toward potentially aggressive persons or animals
Physical separation	Investigate the need and potential for a physical separation between yourself and potentially aggressive persons or animals, you have or can come into contact with.	Evaluate the need and possibilities, and in what situations and circumstances there can be talk of creating a physical separation.	Inform your employer of the situation and take your measures. Ensure that the physical separation is in place.
Breaking contact	Investigate whether you have the need and opportunity for alarming, on call help and self-defence, when or if you come in contact with potentially aggressive persons or animals	Evaluate where there is the need and possibilities, and in what situations and circumstances there can be talk of using an alarm, on call assistance and self-defence.	Inform your employer of the situation and take your measures. Ensure that you know how you must alarm or call for assistance. Learn self-defence techniques
Respect for danger zone	Observe strange or dangerous animals that you can come in contact with and respect the danger zone.	Evaluate whether there is a need for efforts toward other people's securing of their animals. Evaluate whether you have the need for special instruction in dealings with animals.	Inform your employer of the situation and take your measures. Ensure you know how you must act near the danger zone with strange or dangerous animals.
The user's abilities and behaviour	Observe your own behaviour and ability to mix with other people and animals, especially including handling animals that are used in work.	Evaluate your own need for special teaching and training and special procedures for what your behaviour should be.	Inform your employer of the situation and take your measures. Investigate whether there are special instructions and guidelines you can keep to. Show respect for the people and animals you are around.

C 8 INFO CARD for Contact with moving machine parts

In the WORM project, risk types such as these are described through 4 different situations where the risk of contact with machine parts occurs. These include:

1. Work with machines
2. Maintenance of machines
3. Preparing machines
4. Cleaning machines

These 4 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. Physical barriers
2. Control over danger zone
3. User ability
4. Machine's integrity
5. Safety system

Physical barriers is about the necessary safety equipment being in place, whether the safety equipment is in order and used, in addition to whether it ensure complete protection of moving parts, whether there is systematic stop with access to the danger zone and whether there is an emergency stop with errors.

Control over the danger zone is about whether there is access to moving parts/danger zone, whether there is marking and signal upon access to the danger zone and whether the person respects the danger zone.

User ability is about whether the operator has the ability and knowledge for safe use of the machine. Is the operator aware in relation to the danger zone, among others, if it is fixed or dynamic and where there is access to moving machine parts. It is also about space, the person's physical condition and mental awareness about these relationships, and among others, questions about the risk of whether loose hanging hair or clothing can become stuck.

Machine's integrity is about whether the machine is CE-marked, if a risk assessment has been performed with changes to the machine and whether the machine's condition i.e. is in a good state.

Safety system is about whether there is a systematic stop upon access to the danger zone and whether there is an emergency stop in the event of error.

MANAGEMENT

Hazard: Contact with moving machine part

This includes work with technical aids, in addition to maintenance, making ready and cleaning.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Physical barriers	<p>Observe whether the safety equipment is in place and in order, if there is systematic stop upon access to the danger zone and whether there is emergency stop in the event of error</p> <p>Investigate whether the safety equipment is sufficient in relation to the task.</p> <p>Observe whether employees feedback when the equipment is not in order.</p> <p>Observe employee behaviour and use of the equipment.</p>	<p>Evaluate whether the safety equipment is appropriate for the task.</p> <p>Evaluate the maintenance state.</p> <p>Evaluate the need for information to employees and possibly procedures for the work.</p> <p>Evaluate the need for special instruction.</p> <p>Evaluate the need for motivating initiatives for the employees.</p>	<p>Ensure that deficiencies are rectified.</p> <p>Ensure that the correct equipment comes into use.</p> <p>Remove defective equipment.</p> <p>Inform employees about which equipment they must use</p> <p>Inform employees about what equipment is defective or being repaired. Ensure there are procedures for cleaning and maintenance. Motivate and instruct employees about what feedback they must give when they find that things are not in order.</p>
Control over danger zone	<p>Observe whether there is access to moving parts.</p> <p>Observe whether there is an indicator and signal upon access to the danger zone.</p> <p>Observe whether the indicator and signal are visible, functioning and in good condition.</p> <p>Observe whether employees respect indicators and signals.</p>	<p>Evaluate whether the indicator and signal are visible, functioning and in good condition.</p> <p>Evaluate the motivation to ensure maintenance of the indicator and signal.</p> <p>Evaluate the need for special instruction.</p> <p>Evaluate the need for motivating initiatives for the employees.</p>	<p>Ensure that deficiencies are repaired</p> <p>Inform employees about how they shall behave.</p> <p>Motivate and instruct employees about how you want them to behave when indicators and signals are lacking or are not in order.</p>
User ability	<p>Observe whether the employee has the ability and knowledge about safe use of the machine.</p> <p>Observe the employees condition in relation to the space. Observe the employee's attention in relation to access to the danger zone and consciousness regarding the danger zone's dynamics.</p> <p>Observe employee behaviour including about the risk for loose hanging hair or clothing becoming caught.</p>	<p>Evaluate whether employees are OK</p> <p>Evaluate whether employees can handle the task</p> <p>Evaluate whether employees know how their behaviour should be when working with the machine.</p> <p>Evaluate employees' motivation to exhibit safe behaviour</p>	<p>Ensure instructions/agreements are clear</p> <p>Ensure there is a good division of responsibility and tasks</p> <p>Create positive motivation to safe behaviour</p> <p>Ensure there is a consequent attitude for violations</p>
Machine's integrity	<p>Observe whether the machine is CE marked.</p> <p>Observe whether a risk assessment has been performed for changes to the machine. Observe whether the machine is in good order.</p> <p>Observe employees ability to protect the equipment.</p>	<p>Evaluate employees' ability and motivation to set up and use the equipment correctly.</p>	<p>Ensure that deficiencies are repaired</p> <p>Inform employees of the correct working method and ensure that it is used.</p> <p>Instruct about the correct use of the machine. Motivate employees to comply with procedures.</p>

EMPLOYEE			
Hazard: Contact with moving machine part This includes work with technical aids, in addition to maintenance, making ready and cleaning.			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Physical barriers	Observe whether the safety equipment is in place and in order, if there is systematic stop upon access to the danger zone and whether there is emergency stop in the event of error Investigate whether the safety equipment is sufficient in relation to the task in question.	Evaluate whether the safety equipment is appropriate for the task. Evaluate the maintenance state.	Ensure that deficiencies are rectified. Ensure that the correct equipment comes into use. Remove defective equipment. Inform the employer and possibly colleagues, if the conditions are not in order. Follow the given instructions and procedures.
Control over danger zone	Observe whether there is access to moving parts. Observe whether there is marking and signal upon access to the danger zone. Observe whether the indicator and signal are visible, functioning and in good condition.	Evaluate whether the indicator and signal are visible, functioning and in good condition.	Ensure that deficiencies are repaired Inform the employer and possibly colleagues, if the conditions are not in order. Follow the given instructions and procedures.
User ability	Observe whether the employee has the ability and knowledge about safe use of the machine. Observe the need for special behaviour including about the risk for loose hanging hair or clothing becoming caught.	Evaluate your own ability to work safely with the machine. Evaluate whether you can handle the task Evaluate which behaviour is needed in the task for you and your colleagues' safety Evaluate employees' motivation to exhibit safe behaviour	Know the necessary instructions/agreements. Ensure instructions/agreements are clear Ensure there is a good division of responsibility and tasks Ensure that any necessary aids are available and in order. Carry out the task with safe and professional behaviour.
Machine's integrity	Observe whether the machine is CE marked. Observe the machine's condition i.e. whether it is in good order. Observe the need for special measures for protection.	Evaluate your ability to set up and use the equipment correctly.	Ensure that deficiencies are repaired Inform the employer and possibly colleagues, if there are defects and what measures are necessary. Follow the given instructions and procedures.

C 9 INFO CARD for Loss of control over vehicle

In the WORM project, risk types such as these are described through 2 different situations where the risk of loss of control over vehicle occurs. These include:

1. Stops in the vehicle
2. Work in/on the vehicle

These 2 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. People's position
2. Vehicles speed and stability
3. Driver's driving ability
4. Vehicle's condition
5. Loading of the vehicle

People's position is about being at the right place in the vehicles or passengers getting on too early or too late, if persons have parts of the body outside the vehicle or are e.g. on the footboard, cargo area or other parts that are not suited for/intended for persons.

The vehicle's speed and stability is about safe speed, if the vehicle's stability becomes impacted by bad weather, strong wind, driving (close to!) edges, about the loading platform's strength and mounting, errors with stabilising weights (crane) and placing vehicles on unstable surfaces/earth conditions.

The driver's driving ability is about whether the person has a driver's licence for the vehicle in question. It is about the driver's physical condition, whether the driver's attention and placement on the vehicle e.g. getting out too early and whether there is a clear view or a bad view. It is also about the roadway's layout (big enough for the vehicle including manoeuvring), obstacles on the road – also: vehicle settings (fork too low on a forklift), state of the road surface (slippery, uneven) and signalling - Are hazards on the roadway marked?

The vehicle's condition and loading is about the mechanical maintenance (brakes, tyres, steering gear) and whether the load, load conditions, securing, balance and stacking method.

MANAGEMENT

Hazard: Loss of control of VEHICLE

This includes stays in the vehicle and work in/on the vehicle.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
People's position	Investigate where drivers and other persons are on the vehicle while driving, while getting on or off and loading/unloading. Observe employee behaviour on the vehicle.	Evaluate where people can safely be on the vehicle during operation and loading/unloading	Instruct the driver and employees about the correct position on the vehicle during operation, getting on or off and loading/unloading. Motivate employees to maintain a safe position on vehicles.
Vehicle's speed and stability	Observe the loading platform's strength and mounting Observe the possibility that external circumstances can affect the vehicle's stability e.g. inclimate weather, strong wind, driving over edges, faults with stabilising weights (crane) and placement of vehicle on unstable surface/earth conditions. Observe employee behaviour in relation to safe speed.	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance. Evaluate employee ability and motivation to use the vehicle correctly	Ensure that deficiencies are repaired Motivate and inform employees about how you want them to behave in relation to safe driving, and what feedback they shall give when they find things are not in order.
Driver's driving ability	Observe whether drivers have a driving licence for the vehicle in question. Observe the driver's physical state before they go out and drive. Observe whether the vehicle is suited to the selected road (large enough for the vehicle including manoeuvring, obstacles on the road) also: vehicle settings (fork too low on a forklift).	Evaluate whether drivers are OK Evaluate whether drivers can handle the task Evaluate whether drivers know how their behaviour should be when using the vehicle Evaluate the drivers' motivation to exhibit safe behaviour	Ensure instructions/agreements are clear Ensure there is a good division of responsibility and tasks Create positive motivation to safe behaviour Ensure there is a consequent attitude for violations
Vehicle's condition	Observe whether the vehicle is in order, cleaned and maintained (brakes, tyres, steering gear). Observe whether employees feedback when the equipment is not in order. Observe employee behaviour and use of the equipment.	Observe whether the vehicle is in order, cleaned and maintained (brakes, tyres, steering gear). Evaluate the maintenance state. Evaluate the need for remedial measures.	Ensure that deficiencies are rectified. Inform employees about what vehicles are defective or being repaired. Inform employees about which vehicles they must use Ensure there are procedures for cleaning and maintenance. Motivate and instruct employees about what feedback they must give when they find that things are not in order.
Loading of the vehicle	Observe employee's ability to secure the load, load connections, securing, balancing and stacking methods.	Evaluate employee ability to secure the load.	Inform employees about how they secure the load. Ensure there are procedures for stacking methods and securing.

EMPLOYEE

Hazard: Loss of control of VEHICLE

This includes stays in the vehicle and work in/on the vehicle.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
People's position	Investigate where persons are on the vehicle while driving, while getting on or off and loading/unloading.	Evaluate where people can safely be on the vehicle during operation and loading/unloading	Motivate and instruct passengers and colleagues about the right place to be on the vehicle so that passengers do not get on too early or too late, persons have parts of the body outside the vehicle or are e.g. on the footboard, cargo area or other parts that are not suited for/intended for persons. Inform the employer if there are problems getting colleagues to follow instructions.
Vehicles speed and stability	Observe the loading platform's strength and mounting Observe the possibility that external circumstances can influence the vehicle's stability e.g. in climate weather, strong wind, driving over (close to!) edges, faults with stabilising weights (crane) and placement of vehicle on unstable surfaces/ earth conditions.	Evaluate the possibility for sideslipping, tipping. Evaluate the possibility that someone can bump into or affect the equipment's balance.	Ensure that deficiencies are repaired Inform the employer and possibly colleagues, if there are defects and what measures are necessary.
Driver's driving ability	Investigate whether your driver's licence applies to the vehicle in question. Observe your state of health before you drive. Observe whether the vehicle is suited to the selected road (large enough for the vehicle including manoeuvring, obstacles on the road) also: vehicle settings (fork too low on a forklift).	Evaluate whether you are OK Evaluate which behaviour is needed in the task for you and your colleagues' safety .	Know the necessary instructions/agreements. Know who has the responsibility and tasks. Carry out the task with safe and professional behaviour.
Vehicle's condition	Observe whether the vehicle is in order, cleaned and maintained (brakes, tyres, steering gear).	Observe whether the vehicle is in order, cleaned and maintained (brakes, tyres, steering gear). Evaluate the maintenance state. Evaluate the need for remedial measures.	Ensure that deficiencies are rectified. Inform the employer and possibly colleagues, if the conditions are not in order. Follow the given instructions and procedures.
Loading of the vehicle	Observe the load, load connections, securing and balance and stacking method.	Evaluate employee ability to secure the load.	Follow procedures for stacking methods and securing.

C 10 INFO CARD for Contact with electricity

In the WORM project, risk types such as these are described through 2 different situations where the risk of contact with electricity occurs. These include:

1. Work with electricity
2. Work with technical aids

These 2 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 4 generic safety barriers, namely questions of:

1. Protection against live parts/electric arcs/ nearness to non-insulated active parts
2. Protection against electricity in earth
3. Safeguarding against access
4. Procedure if affected by electricity

Protection against live parts/electric arcs/nearness to non-insulated active parts is about whether the live parts are sufficiently protected e.g. about installation of double insulating tools and the use of low voltage equipment based upon needs and legislation. Or whether the live parts are not protected, but should be, whether they are protected but insufficiently or if the protection has been wilfully removed. It is about whether it is protected against proximity of unisolated parts, or if one is intentionally too close, whether installation is carried out under voltage and whether there is space for manoeuvring. Finally, whether there is protection against burns when working with an electric arc.

Protection against electricity in earth is about the necessary personal protective devices being used, such as rubber footwear as double insulation.

Safeguarding against access is about, access protection being respected, that there are procedures for securing against unauthorised access and that ignoring of access protection does not occur.

Procedure if affected by electricity is about, knowledge about whether others have experience if one receive an electric shock, and own experience with regard to help if others get an electric shock.

MANAGEMENT

Hazard: for contact with ELECTRICITY

This includes work with/near high-voltage lines, with electricity and with technical aids.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Protection against live parts/electric arcs/ nearness to non-insulated active parts	<p>Observe whether double insulation is installed on tools and whether low-voltage equipment is used based upon needs and legislation.</p> <p>Observe whether the live parts are sufficiently protected</p> <p>Evaluate whether the protection is in order.</p> <p>Observe whether the live parts are visible, whether there are signals about voltage on the line/high-voltage</p> <p>Observe whether there is space for manoeuvring.</p> <p>Observe whether there is protection against burns when working with an electric arc.</p>	<p>Observe whether double insulation is installed on tools and whether low-voltage equipment is used based upon needs and legislation.</p> <p>Evaluate whether the live parts are sufficiently protected e.g. whether they are not but should be, whether they are protected but insufficiently or if the protection has been wilfully removed.</p> <p>Evaluate the need for special instruction.</p> <p>Evaluate whether there is sufficient protection against burns when working with an electric arc.</p>	<p>Ensure that deficiencies are repaired</p> <p>Inform employees about how they shall behave.</p> <p>Motivate and instruct employees about how you want them to behave when protection is lacking or is not in order.</p>
Protection against electricity in earth	<p>Investigate whether the necessary personal protective devices are used such as rubber footwear as double insulation.</p>	<p>Evaluate the motivation to use personal protective devices such as rubber footwear and double insulation.</p>	<p>Ensure there are personal protective devices available.</p> <p>Instruct employees in the use of personal protective devices.</p> <p>Motivate and instruct employees about how you want them to behave when protection is lacking or is not in order.</p>
Safeguarding against access	<p>Investigate whether safeguarding against access is sufficient and in order.</p> <p>Investigate whether safeguards against access are respected.</p> <p>Investigate whether there are procedures against unauthorised access.</p>	<p>Evaluate whether safeguards against access are respected or if there is conscious ignoring of safeguards against access.</p> <p>Evaluate whether there should be procedures for unauthorised access.</p>	<p>Ensure that you intervene if safeguards against access are not respected.</p> <p>Motivate and instruct employees about how they shall behave if safeguards against access are not respected.</p>
Procedure if affected by electricity	<p>Investigate whether there are procedures/emergency plan in the event of electrical influence.</p> <p>Investigate whether employees are trained in first aid for electric shock.</p>	<p>Evaluate whether the procedure for electrical influence is in order.</p> <p>Evaluate employee training in first aid.</p>	<p>Instruct employees in the procedure.</p> <p>Ensure that employees are trained in the procedure with regular exercises.</p>

EMPLOYEE

Hazard: for contact with ELECTRICITY

This includes work with/near high-voltage lines, with electricity and with technical aids.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Protection against live parts/electric arcs/nearness to non-insulated active parts	Observe whether double insulation is installed on tools and whether low-voltage equipment is used based upon needs and legislation. Observe whether the live parts are sufficiently protected Observe whether there is space for manoeuvring.	Evaluate whether double insulation is installed on tools and whether low-voltage equipment is used based upon needs and legislation. Evaluate whether the live parts are sufficiently protected Evaluate whether there is voltage on the line. Evaluate whether there is space for manoeuvring.	Inform management about faults and deficiencies. Do not perform work if the live parts are not sufficiently protected.
Protection against electricity in earth	Investigate whether the necessary personal protective devices such as rubber footwear as double insulation are available.	Evaluate whether the personal protective devices are sufficient and whether they are in order.	Inform management about faults and deficiencies. Do not perform the work if the necessary personal protective devices are not available.
Safeguarding against access	Investigate whether safeguarding against access is sufficient and in order. Investigate whether there are procedures for unauthorised access.	Evaluate whether unauthorised persons respect access safeguards or if they are consciously ignored.	Inform management if access safeguards are not respected. Motivate and instruct unauthorised persons to respect the access safeguards and intervene if they are not respected, .
Procedure if affected by electricity	Investigate whether there are procedures/emergency plan in the event of electrical influence. Investigate whether your colleagues are trained in first aid for electric shock.	Evaluate whether the procedure/emergency plan for electrical influence is in order. Evaluate your own and your colleagues' experience and training in first aid for electric shock.	Participate in first aid courses. Participate in exercises in emergency plan. Help colleagues in the case of an accident. Follow the emergency plan.

C 11 INFO CARD for Burning from heat/cold

In the WORM project, risk types such as these are described through 3 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work at/with cold surfaces
2. Work at/with warm surfaces
3. Work at/with naked fire

These 3 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 6 generic safety barriers, namely questions of:

1. Access protection,
2. Personal protective devices and other protection
3. Temperature control
4. Equipment's state and insulation
5. Object's placement
6. Placement of parts of the body

Access protection is about physical barriers and signals, which warn about risk.

Personal protective devices and other protection is about the use of gloves, masks, fire proof clothing.

Temperature control is about monitoring/control of surroundings, the weather and air temperature, and temperature control of technical aids.

The equipment's condition and insulation is about the machine's condition, which can lead to overheating and process state, which can lead to overheating and heat insulation of warm/cold surfaces in relation to this.

Object's placement is about incorrect placement of warm/cold items, incorrect time for heating/cooling of items, movement of warm parts, items, ash, etc.

Placement of body parts is about grip in warm/cold items, lack of knowledge about warm/cold items and the intervention against warm/cold items to counteract other risk.

MANAGEMENT

Hazard: for burning

This includes with by/with warm/cold surfaces or naked flame

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Access protection	Investigate whether the physical barriers are sufficient. Investigate whether there are signals, which warn of risk in a sufficient scope. Investigate whether employees respect barriers and signals.	Evaluate whether the physical barriers and signals are maintained and in order. Evaluate employee behaviour.	Ensure that the physical barriers and signals are cleaned, maintained and in order. Instruct employees.
Personal protective devices and other protection	Investigate whether there are the necessary personal protective devices and special working clothes available. Investigate whether they are CE marked, effective in relation to the task and whether they are cleaned and in order. Investigate whether employees use the personal protective devices.	Evaluate the personal protective devices such as gloves, masks and fireproof clothing, among others, regarding quality and suitability. Evaluate procedures for the use of personal protective devices. Evaluate employee behaviour.	Ensure that the necessary personal protective devices and the special work clothes are available and in order. Ensure cleaning, maintenance and regular replacement of the same. Ensure there are procedures for use.
Temperature control	Investigate whether there is sufficient monitoring/control of temperatures in surroundings, weather and air, and technical aids. Investigate whether monitoring/control is sufficient and works and whether it is maintained and calibrated. Investigate employee behaviour.	Investigate whether there is sufficient monitoring/control of temperatures in surroundings and in technical aids. Evaluate whether monitoring/control is sufficient and works. Evaluate employee behaviour in relation to temperature control.	Ensure there is sufficient monitoring/control of temperatures. Ensure there is even calibration, cleaning, repairs and maintenance. Ensure there are procedures for action. Motivate and instruct employees about how you want them to behave if the temperature control is lacking or is not in order.
Equipment's state and insulation	Investigate machines and processes potential for overheating. Investigate whether they are protected against overheating and/or whether the surface's insulation is sufficient.	Evaluate whether it is sufficiently protected against overheating and/or whether the surface's insulation is sufficient to protect against subsection.	Ensure that machines and processes are protected in relation to overheating and ensure there is sufficient insulation against this. Inform employees of hazards and about safe behaviour.
Object's placement	Investigate placement of warm/cold items.	Evaluate whether there is incorrect placement of warm/cold items, incorrect time for heating/cooling of items, movement of warm parts, items, ash, etc.	Ensure that you protect effectiveness against the risk for warm/cold items. Ensure there is information for employees about the risk for subsection.
User ability	Investigate whether employees are familiar with and are conscious of the risk of subsection to warm/cold items.	Evaluate employee behaviour.	Train employees in safe behaviour. Motivate and instruct employees about how you want them to behave.

EMPLOYEE

Hazard: for burning with work by/with warm/cold surfaces or naked fire

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Access protection	Investigate whether the physical barriers are in place and in order. Investigate whether there are signals, which warn of risk.	Evaluate whether the physical barriers and signals are maintained and in order.	Ensure you report errors and deficiencies to management. Do not perform the work if barriers and signals are not in order. Respect signals and barriers. Follow instructions.
Personal protective devices and other protection	Investigate whether there are the necessary personal protective devices and special working clothes available.	Evaluate the personal protective devices such as gloves, masks and fireproof clothing, among others, regarding quality and suitability.	Use the necessary personal protective devices and the special working clothes. Follow procedures for use. Ensure you report errors and deficiencies to management. Do not perform the work if personal protective devices and special working clothes are not available.
Temperature control	Investigate whether there is sufficient monitoring/control of temperatures in surroundings, weather and air, and technical aids.	Evaluate whether there is sufficient monitoring/control of temperatures in surroundings and in technical aids.	Be aware of monitoring/control of temperatures. Follow procedures for action. Ensure you report errors and deficiencies to management. Do not perform the job if the temperature control is defective.
Equipment's state and insulation	Investigate machines and processes in relation to the potential for overheating. Investigate whether the surface's insulation is intact. Investigate the emergency plan in case of overheating.	Evaluate machines and processes in relation to the potential for overheating. Evaluate whether the surface's insulation is intact. Evaluate the emergency plan in case of overheating.	Follow your manager's instructions for safe behaviour in case of overheating. Ensure you report errors and deficiencies to management. Do not perform the job if the insulation is defective. Follow the emergency plan in case of overheating.
Object's placement	Investigate placement of warm/cold items.	Investigate placement of warm/cold items.	Follow management's instructions for avoiding subsection to warm/cold items.
User ability	Investigate the risk of subsection to warm/cold items.	Evaluate the risk of subsection to warm/cold items.	Exercise safe behaviour.

C 12 INFO CARD for Acid etching/poisoning by contact with hazardous chemicals

In the WORM project, risk types such as these are described through 6 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work by/with open containers with hazardous chemicals that can spill
2. Work near uncovered hazardous chemicals
3. Work with filling or tapping of hazardous chemicals
4. Transport of closed containers with hazardous chemicals
5. Closing of containers with hazardous chemicals
6. Activities/work near closed containers with chemicals

These 6 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. Container's condition and placement
2. Process control and monitoring
3. Ventilation
4. Personal protective devices
5. User ability, behaviour and access

The container's and associated equipment's condition and placement is about these being suited to the chemical used, that they shall be present, stored and placed appropriately and in a good state.

By the container's state, it is means that a lid/covering is placed on the container and there is a sufficient physical covering/protection of the hazardous substances, that the container's sides are in a good state, that the container/the system including openings mechanism can resist external influence from people, such as pushing or blows and that the container/the system can resist impact due to tipping or falling over.

The container's placement refers to placing open containers in places where one cannot bump into them and so they are protected against external influences such as collision and falling objects, that they are protected against impact due to tipping over or falls, and that the container is placed on a stable foundation (not on the edge), where they are supported sufficiently and secured as needed, and that the container's cables, lines, etc. are not in the way for employees.

In addition, that hazardous substances are stored in the correct packaging and stored correctly, that they are secured against incompatible substances coming in contact with each other, that devices are placed so that they cannot come in contact with hazardous substances.

The equipment's state refers to the container's connected elements (handles, pipes, valves, instruments) are in good condition and seals are made correctly, that elements are connected correctly and are sufficiently tight, that the containers/systems are connected correctly to the rest of the system, that the containers/systems (seals) are constructed out of the correct materials, that pipes and hoses are connected correctly and tight, that the containers/systems connections (pipes, seals) do not show signs of wear (erosion) or corrosion and are not damaged due to external influences.

Process control and monitoring is about the process being planned and carried out so that uncontrolled emissions do not occur underway, and that it is monitored sufficiently so that it is possible to intervene if errors occur.

Process control refers to the container not being filled to the edge, that the container's contents do not run out over the edge, that there is an even distribution of heat in the container during the process, and that

the container does not suddenly become warm, that substances with a significant difference in temperature or that are incompatible substances do not come in contact with each other, that part of the chemicals do not remain in the container when it is emptied, that reactive substances are mixed in the correct conditions and/or in the right order, to add and mix chemicals occurs with caution, that the correct substances are used. Finally, that chemicals are supplied with the correct labels, and that objects are handled cautiously in the proximity of containers.

Also that the process conditions and cleaning procedures ensure that outflow can be stopped including with it wrongly being closed, that accumulated gasses/steam can be released, that the correct substances are used, that the correct quantities of substances are used/avoiding too high quantities/concentrations, that there is sufficient/correct cleaning after the use of hazardous substances to prevent part of the chemicals remaining in the container when it is emptied.

Monitoring refers to checking after securing/closing off/shutting off a closed system if this is shut correctly with the aid of their senses (possibly in combination with equipment such as a mirror glass), with the aid of measuring equipment, by keeping an eye on audio and light signals that indicate whether the system is running, by seeing whether the valves are in a correct position and ducts are switched/connected from onto the correct place to see whether the system is empty/clean/without pressure/cooled down.

Ventilation is about ensuring that hazardous gasses/steam are lead away

Personal protective devices refers to that the prescribed personal protective devices and safety measure exist and are used correctly.

User ability, behaviour and access is about employees having the knowledge and skills to use equipment and chemicals correctly, that employees handle chemicals with the necessary caution and that it is ensured that no one is where there are hazardous substances.

User ability refers to employees handling containers with care and caution in the proximity of containers, that employees use their senses (possibly in combination with equipment such as a mirror glass), and keep an eye on audio and light signal that indicate whether the system is running. Prevent against coming in contact with hazardous substances.

By behaviour, it is meant that employees respect and take action on (signs, labels, displays, audio and visual alarms) and clear warnings and/or pictograms on the container that warn against opening of the container/closed system.

Access refers to preventing oneself or others from coming into contact with hazardous substances.

MANAGEMENT

Hazard: Contact with hazardous chemicals This includes work with open containers with hazardous chemicals, filling, tapping or closing of containers, transport of and activities/work with closed containers with hazardous chemicals,			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Container's condition and placement	Investigate whether the container and equipment are suited for the used chemicals, that they are in place, stored , placed appropriately and in a good state.	Evaluate whether the container and equipment are suited for the used chemicals, that they are in place, stored, placed appropriately and in a good state.	Ensure that there are suitable containers and equipment available. Ensure there is safe placement and storage. Ensure that repairs, maintenance and cleaning are performed.
Process control and monitoring	Observe whether processes are planned and carried out so that uncontrolled spills do not occur underway. Observe that it is monitored sufficiently, so that one can intervene if an error occurs.	Evaluate whether processes are planned and carried out so that uncontrolled spills do not occur underway. Evaluate that it is monitored sufficiently, so that one can intervene if an error occurs.	Ensure that processes are planned and carried out so that uncontrolled spills do not occur underway. Ensure there is sufficient monitoring, so that one can intervene if an error occurs. Ensure there are procedures and training in process control and monitoring.
Ventilation	Observe whether ventilation is sufficient that hazardous gasses/steam are led away efficiently.	Evaluate whether ventilation is sufficient that hazardous gasses/steam are led away efficiently.	Ensure there is sufficient ventilation. Ensure that repairs, maintenance and cleaning are performed. Instruct employees in the use of ventilation.
Personal protective devices	Investigate requirements for personal protective devices and safety measures in the safety data sheets. Observe whether the prescribed personal protective devices and safety measures are available and used correctly.	Evaluate requirements for personal protective devices and safety measures in the safety data sheets. Evaluate whether the prescribed personal protective devices and safety measures are available and used correctly.	Ensure there are workplace user instructions/procedures for the use of personal protective devices. Ensure that the prescribed personal protective devices and safety measures are in place and in order.
User ability, behaviour and access	Observe whether employees have the knowledge and ability to use equipment and chemicals correctly Observe whether employees handle chemicals with the necessary caution, observe that unauthorised persons are not where there is hazardous substances.	Evaluate whether employees have the knowledge and ability to use equipment and chemicals correctly Evaluate whether employees handle chemicals with the necessary caution, evaluate whether unauthorised persons are where there are hazardous substances.	Ensure that employees are trained and instructed in controlling processes, using equipment and chemicals correctly. Motivate and instruct employees regarding safe behaviour when working with hazardous chemicals. Ensure that access is prevented by unauthorised persons to areas with hazardous chemicals.

EMPLOYEE

Hazard: Contact with hazardous chemicals

This includes work with open containers with hazardous chemicals, filling, tapping or closing of containers, transport of and activities/work with closed containers with hazardous chemicals,

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Container's condition and placement	Investigate whether the container and equipment are suited for the used chemicals, that they are in place, stored, placed appropriately and in a good state.	Evaluate whether the container and equipment are suited for the used chemicals, that they are in place, stored, placed appropriately and in a good state.	Use suitable containers and equipment. Ensure there is safe placement and storage.
Process control and monitoring	Observe whether processes are planned and carried out so that uncontrolled spills do not occur underway. Observe that it is monitored sufficiently, so that one can intervene if an error occurs.	Evaluate whether processes are planned and carried out so that uncontrolled spills do not occur underway. Evaluate whether it is monitored sufficiently, so that one can intervene if an error occurs.	Carried out, so that uncontrolled spills do not occur underway. Take action if the monitoring shows wrong. Follow procedures for process control and monitoring.
Ventilation	Observe whether ventilation is sufficient that hazardous gasses/steam are led away efficiently.	Evaluate whether ventilation is sufficient that hazardous gasses/steam are led away efficiently.	Use sufficient ventilation.
Personal protective devices	Investigate requirements for personal protective devices and safety measures in the workplace user instructions. Observe whether the prescribed personal protective devices and safety measures are available and can be used correctly.	Evaluate requirements for personal protective devices and safety measures in the workplace user instructions. Evaluate whether the prescribed personal protective devices and safety measures are available and can be used correctly.	Follow workplace user instructions. procedures for the use of personal protective devices.
User ability, behaviour and access	Observe whether you have the knowledge and ability to use equipment and chemicals correctly Investigate whether you handle chemicals with the necessary caution, observe whether unauthorised persons are where there is hazardous substances.	Observe whether you have the knowledge and ability to use equipment and chemicals correctly Evaluate whether you handle chemicals with the necessary caution, Evaluate whether unauthorised persons can be where there are hazardous substances	Follow instructions for safe behaviour when working with hazardous chemicals. Ensure that access is prevented by unauthorised persons to areas with hazardous chemicals.

C 13 INFO CARD for Overloading when working with heavy loads

In the WORM project, risk types such as these are described through 2 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work with heavy/unmanageable objects
2. Activities around this

These 2 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 4 generic safety barriers, namely questions of:

1. Working position
2. Strength
3. Control over the body
4. Technical aids

Working position is about that there being a possibility for good working positions and handling possibilities of objects that are easy to drop.

Strength is about being fit and healthy in relation to lifting heavy loads, about not using too much strength in relation to the load's weight, and ensuring that loads are not too heavy.

Control over the body is about the body being in good physical condition, so that the lifting of loads can occur under appropriate conditions e.g. through calm movements, without running and panic, without subjection to slippery floors, with the use of appropriate footwear, with good balance ability and without an unstable foundation, uneven foundation and obstacles.

Technical aids are about the aid functioning correctly, that it is in good condition, that the right aid is used and used correctly, also that the foundation is in order with the use of the aid so that, among others, jumping is avoided.

MANAGEMENT

Hazard: for overloading

These includes work with heavy/unmanageable objects or with moving around

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Working position	Investigate whether there are possibilities for good working positions and handling possibilities of objects that are easy to drop.	Evaluate whether there are possibilities for good working positions and handling possibilities of objects that are easy to drop.	Ensure that there is the possibility for good working positions and handling possibilities of objects that are easy to drop. Instruct employees. Motivate and instruct employees about how they shall act if it is not possible to assume good working positions.
Strength	Investigate whether employees are healthy and fit in relation to lifting heavy loads. Investigate whether loads are too heavy. Investigate whether employees know good lifting techniques, so they do not have to use much force when lifting loads. Investigate employee behaviour.	Evaluate whether employees are healthy and fit in relation to lifting heavy loads. Evaluate whether loads are too heavy. Evaluate whether employees have sufficient knowledge regarding good lifting techniques. Evaluate employee behaviour.	Avoid getting employees to lift heavy loads if they are not fit for doing so. Ensure that loads are not too heavy. Ensure that employees are trained in good lifting techniques. Motivate and instruct employees about how they shall act if it is not possible to assume good working positions.
Control over the body	Investigate whether the lifting of loads can occur under appropriate conditions. For example, using calm movements, without running and panic, without being subjected to slippery floors, with the use of appropriate footwear, with good balance and without unstable foundations, uneven foundations and obstacles. Investigate employee behaviour.	Evaluate whether lifting can occur under appropriate conditions. Evaluate employee behaviour.	Ensure that the lifting of loads can occur under appropriate conditions. Instruct employees. Motivate and instruct employees about how they shall act if it is not possible to assume good working positions.
Technical aids	Investigate whether the necessary technical aids are available. Investigate whether the aids function correctly, are in good condition and that the right aid is used and used correctly. Also whether the foundation is in order. Investigate whether employees use the technical aids.	Evaluate whether the necessary technical aids are available to avoid or reduce subjection for heavy lifting. Evaluate whether the aids function correctly, are in good condition, that the right aid is used and used correctly, whether the foundation is in order. Evaluate employee behaviour.	Ensure that the necessary technical aids are available. Ensure that the aids function correctly, are in good order. Instruct employees in the use of technical aids. Motivate and instruct employees about how they shall act if aids are not in order.

EMPLOYEE

Hazard: for overloading

These includes work with heavy/unmanageable objects or with moving around

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Working position	Investigate whether there are possibilities for good working positions and handling possibilities of objects that are easy to drop.	Evaluate whether there are possibilities for good working positions and handling possibilities of objects that are easy to drop.	Follow instructions. Ensure you report errors and deficiencies to management. Do not perform the work if it is not possible to assume good working positions when lifting heavy or manageable loads.
Strength	Investigate you are healthy and fit in relation to lifting heavy loads. Investigate whether loads are too heavy. Investigate whether you know good lifting techniques.	Evaluate whether you are healthy and fit in relation to lifting heavy loads. Evaluate whether loads are too heavy. Evaluate whether you believe that you have sufficient knowledge of lifting techniques in relation to the concrete task.	Avoid lifting heavy loads if you are not fit for doing so. Do not lift loads that are too heavy. Participate in training in good lifting techniques and use good lifting techniques.
Control over the body	Investigate whether the lifting of loads can occur under appropriate conditions. For example, using calm movements, without running and panic, without being subjected to slippery floors, with the use of appropriate footwear, with good balance and without unstable surfaces, uneven surfaces and obstacles.	Evaluate whether lifting can occur under appropriate conditions.	Follow instructions. Ensure you inform management if lifting cannot be carried out appropriately. Do not perform the work if it is not possible to assume good working positions when lifting heavy or unmanageable loads.
Technical aids	Investigate whether the necessary technical aids are available. Investigate whether aids function correctly, are in a good state and whether the foundation is in order. Investigate whether you know how the technical aids shall be used.	Evaluate whether the necessary technical aids are available to avoid or reduce subjection for heavy lifting. Evaluate whether the aids function correctly, are in good condition, that the right aid is used and used correctly, whether the foundation is in order.	Follow instruction on the use of technical aids. Ensure you inform management if lifting cannot be carried out appropriately. Avoid performing the work if it is not possible to use the necessary technical aids.

D 14 INFO CARD for Contact with High Voltage

In the WORM project, risk types such as these are described through 6 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work at/near high-voltage lines including lines at trains and tramways, etc.

This risk type has different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 5 generic safety barriers, namely questions of:

1. Line protection
2. Protection against live parts/electric arcs/ nearness to non-insulated active parts
3. Protection against electricity in earth
4. Safeguarding against access
5. Procedure when working near high-voltage cables

Line protection refers to high-voltage lines being protected in a sufficient scope so contact can be avoided with signal, sign, warning, physical barriers, also that the lines are sufficiently protected in relation to tools, cranes and vehicles.

Protection against live parts/electric arcs/ nearness to non-insulated active parts is about attention and/or knowledge of whether there is high-voltage, whether there is visibility of the current-carrying parts, whether there are signals/communication about high-voltage. Finally it is about whether there is space for manoeuvring, whether the necessary personal protective devices such as gloves, face guards are used.

Protection against electricity in earth is about the necessary personal aids being used, such as rubber footwear as double insulation.

Protection against access refers to access protection being respected.

Procedure for electrical influence/working near high-voltage cables is about knowledge of procedures when working in a vehicle close by high-voltage lines.

MANAGEMENT

Hazard: for contact with HIGH-VOLTAGE
This includes work at/near high-voltage lines.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Cable protection	Observe whether the electric cables are sufficiently protected and whether they are maintained and in order so contact can be avoided by signal, sign, warning, physical barrier. Also that the cables are sufficiently protected in relation to tools, cranes and vehicles.	Evaluate whether there is a need for additional protection. Evaluate whether there is a need for additional warnings/signs. Evaluate the need for information to employees. Evaluate the need for motivating initiatives for the employees.	Ensure that deficiencies are rectified. Ensure there are procedures for work and for cleaning and maintenance. Motivate and instruct employees about how you want them to act when they work at/near high-voltage lines and what feedback they must give when they find that things are not in order.
Protection against live parts/electric arcs/nearness to non-insulated active parts	Observe employee attention, knowledge and communication if there is high-voltage. Observe whether parts with high-voltage are visible, whether there are signals/communication regarding high-voltage. Observe whether there is space for manoeuvring. Observe whether the necessary personal protective devices are available and whether they are used.	Evaluate employee behaviour, attention and/or knowledge and communication about high-voltage. Evaluate the need for special instruction. Evaluate the need for motivating initiatives for the employees.	Ensure that deficiencies are repaired Ensure there are the necessary personal protective devices. Inform and instruct about the use of personal protective devices. Instruct employees about how they shall behave. Motivate and instruct employees about how you want them to behave when protection is lacking or is not in order.
Protection against electricity in earth	Investigate whether the necessary personal aids are used such as rubber footwear as double insulation.	Evaluate the motivation to use personal protective aids such as rubber footwear and double insulation.	Ensure there are personal aids available. Instruct employees in the use of personal protective aids. Motivate and instruct employees about how you want them to behave when protection is lacking or is not in order.
Safeguarding against access	Investigate whether safeguards against access are respected. Investigate whether there are procedures for unauthorised access.	Evaluate whether safeguards against access are respected or if there is conscious ignoring of safeguards against access. Evaluate whether there should be procedures for unauthorised access.	Ensure that you intervene if safeguards against access are not respected. Motivate and instruct employees about how they shall behave if safeguards against access are not respected.
Procedure if affected by electricity	Investigate whether there are procedures/emergency plan when working in a vehicle close to high-voltage lines. Investigate whether employees are trained in first aid for electric shock.	Evaluate whether procedures for working in a vehicle close by high-voltage lines are in order. Evaluate employee training in first aid.	Instruct employees in the procedures. Ensure that employees are trained in the procedures with regular exercises.

EMPLOYEE			
Hazard: for contact with HIGH-VOLTAGE This includes work at/near high-voltage lines.			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Cable protection	Observe whether the electrical cables are sufficiently protected so contact is avoided and whether they are sufficiently protected in relation to tools, cranes and vehicles. Observe signals, signs, warnings and physical barriers.	Evaluate whether there is a need for additional protection. Evaluate signals, signs, warnings and physical barriers.	Inform management about faults and deficiencies. Do not perform the work if protection is not in order. Respect the physical barriers. Respect signals and signs.
Protection against live parts/electric arcs/ nearness to non-insulated active parts	Observe whether parts with high-voltage are visible, whether there are signals/communication regarding high-voltage. Observe whether there is space for manoeuvring. Investigate whether the necessary personal protective devices are available.	Evaluate whether there is voltage on the line. Evaluate whether there is space for manoeuvring. Investigate whether the necessary personal protective devices are available and in order.	Inform management about faults and deficiencies. Use the necessary personal protective devices. Be aware of whether there is high-voltage and ensure there is good communication to colleagues at high-voltage.
Protection against electricity in earth	Investigate whether the necessary personal aids such as rubber footwear as double insulation are available.	Evaluate whether the personal aids are sufficient and whether they are in order.	Inform management about faults and deficiencies. Do not perform the work if the necessary personal aids are not available.
Safeguarding against access	Investigate whether safeguarding against access is sufficient and in order. Investigate whether there are procedures for unauthorised access.	Evaluate whether access safeguards are respected by unauthorised person or if they are consciously ignored.	Inform management if access safeguards are not respected. Motivate and instruct unauthorised persons to respect the access safeguards and intervene if they are not respected, .
Procedure if affected by electricity	Investigate whether there are procedures/emergency plan when working in a vehicle close to high-voltage lines. Investigate whether your colleagues are trained in first aid for electric shock.	Evaluate whether procedures for working in a vehicle close by high-voltage lines are in order. Evaluate your own and your colleagues' experience and training in first aid for electric shock.	Participate in first aid courses. Participate in exercises in emergency plan. Help colleagues in the case of an accident. Follow procedures when working in a vehicle close to high-voltage lines. Follow the emergency plan.

D 15 INFO CARD for Combustion and Asphyxiation in the event of a fire

In the WORM project, risk types such as these are described through 3 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work near fire, hot work
2. Work near flammable, inflammable materials
3. Fire extinction

These 3 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 4 generic safety barriers, namely questions of:

1. Use of work/spark permit
2. Explosion protection
3. Personal protective devices and clothing
4. Protection against fire

Use of the work/spark permit is about good protection in when working in areas with the risk for explosive vapour and/or work with combustible material in areas that are protected against ignition sources. This shall ensure against hot work being performed where it is not permitted, or that hot work is used unnecessarily, that ignition cannot occur due to the conduction of heat from radiators, or from insufficient cooling down period, e.g. when roofing or uncontrolled ignition e.g. from oven. It is about avoiding the use of flammable fluids for cleaning in areas with ignition sources, or the use of flammable fluids with a low autogenous ignition temperature, when non-hazardous materials could be used e.g. the use of diesel oil instead of for petrol for ignition when burning branches. It is about ensuring that materials cannot be polluted with flammable fluids, about the subjection for warm surfaces close by flammable fluids or ineffective cooling/ventilation.

Explosion protection is about avoiding the use of flammable material when it is possible to limit the use of flammable materials, to protect against sparking in areas with explosive vapour by using explosion-proof equipment and avoid the formation of static electricity It is about protecting against the unintentional discharge of flammable materials by safe storage, by equipment being secure e.g. by safety valves blowing to safe areas, and it is about knowing whether materials are flammable through the correct labelling of packaging.

Personal protective devices and clothing are about clothing protecting against fire, not giving rise to static electricity and that clothing is not polluted e.g. with oil. Also that there with the risk for subjection to heat, smoke and direct fire used the necessary personal protective aids/clothing, which protects against fire including full breathing protection. Also that persons, who will be close by flames, strong heat and explosive gasses are only subjected to such loads for a short time e.g. by keeping at a reasonable distance from fire and ultimately it is about ensuring against persons being subjected to heat or poisonous vapour.

Protection against fire is about prohibition against smoking and the prevention of arson.

MANAGEMENT

Hazard: for combustion and asphyxiation/inhalation of poisonous materials

This includes work near fire, hot work, work near combustible, inflammable materials and when fire fighting.

Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Use of work/spark permit	Observe whether work/spark permit is used in all work with the risk of fire and explosion Observe whether employees respect agreements and instructions in the spark permits including good termination of the work.	Evaluate whether the use of work/spark permit effectively protects against fire and explosion. Observe whether employees respect agreements and instructions in the spark permits including good termination of the work.	Ensure there are procedures for work and work/spark permits. Motivate and instruct employees about how you want them to act when they work in areas with the risk of fire/explosion and what feedback they must give when they find that things are not in order.
Safeguarding against explosion	Observe whether the use of flammable materials is avoided/limited in a sufficient scope. Observe whether explosion-proof equipment is used and the formation of static electricity is avoided. Observe whether flammable materials are stored safely and whether equipment is sufficiently closed and whether any safety valves etc. blow to safe areas. Observe whether hazardous chemicals are correctly labelled.	Evaluate whether explosion-proof equipment is used and the formation of static electricity is avoided in areas with explosive vapour. Observe whether flammable materials are stored safely and whether equipment is sufficiently closed and whether any safety valves etc. blow to safe areas. Observe whether hazardous chemicals are correctly labelled.	Ensure that it is secured against fire and explosion risk in relation to legislation in the area. Inform employees about the risks.
Personal protective devices and clothing	Observe whether clothing and personal protective devices protect effectively against fire and the generation of static electricity. Observe whether clothing and personal protective devices are kept clean and in order. Observe whether employees use the necessary personal protective devices and keep at a safe distance from flames, heat, smoke and poisonous gasses.	Observe whether clothing and personal protective devices protect effectively against fire and the generation of static electricity. Observe whether clothing and personal protective devices are kept clean and in order. Observe whether employees use the necessary personal protective devices and keep at a safe distance from flames, heat, smoke and poisonous gasses.	Ensure that clothing and personal protective devices are available and in order. Ensure that they are cleaned, repaired and maintained. Ensure there are procedures for use, etc. Motivate and instruct employees about how you want them to behave when they find that things are not in order.
Protection against fire	Observe whether the ban on smoking is adhered to. Observe whether it, to a sufficient extent, is protected against unauthorised access to flammable fluids and areas with the risk of fire/explosion. Observe employee behaviour in relation to good fire hygiene.	Evaluate whether the ban on smoking is adhered to. Evaluate whether it, to a sufficient extent, is protected against unauthorised access to flammable fluids and areas with the risk of fire/explosion. Evaluate employee behaviour in relation to good fire hygiene.	Ensure there is a ban on smoking. Ensure there is protection against unauthorised access to hazardous areas. Motivate and instruct employees about good fire hygiene and protection against arson.

EMPLOYEE

<p>Hazard: for combustion and asphyxiation/inhalation of poisonous materials This includes work near fire, hot work, work near combustible, inflammable materials and when fire fighting.</p>			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Use of work/spark permit	Observe whether work/spark permit is used in all work with the risk of fire and explosion	Evaluate whether the use of work/spark permit effectively protects against fire and explosion.	Follow procedures for work and work/spark permits. Inform management about faults and deficiencies. Do not perform work if a spark permit is lacking, or if protection in relation to the spark permit is not in order.
Safeguarding against explosion	Observe whether explosion-proof equipment is used and the formation of static electricity is avoided in areas with explosive vapour. Observe whether flammable materials are stored safely and whether equipment is sufficiently closed and whether any safety valves etc. blow to safe areas. Observe whether hazardous chemicals are labelled.	Evaluate whether explosion-proof equipment is used and the formation of static electricity is avoided in areas with explosive vapour. Observe whether flammable materials are stored safely and whether equipment is sufficiently closed and whether any safety valves etc. blow to safe areas. Evaluate whether hazardous chemicals are labelled.	Respect rules for explosion protection. Inform management about faults and deficiencies.
Personal protective devices and clothing	Observe whether clothing and personal protective devices protect effectively against fire and the generation of static electricity. Observe whether clothing and personal protective devices are kept clean and in order.	Observe whether clothing and personal protective devices protect effectively against fire and the generation of static electricity. Observe whether clothing and personal protective devices are kept clean and in order.	Use the necessary clothing and personal protective devices. Follow procedures for use, etc. Inform management about faults and deficiencies.
Protection against fire	Observe whether the ban on smoking is adhered to. Observe whether there, in a sufficient scope, is secured against unauthorised access to flammable fluids and areas with the risk of fire/explosion. Observe whether there is good fire hygiene.	Evaluate whether the ban on smoking is adhered to. Evaluate whether it, to a sufficient extent, is secured against unauthorised access to flammable fluids and areas with the risk of fire/explosion. Evaluate whether there is good fire hygiene.	Follow any ban on smoking. Respect protection against unauthorised access to hazardous areas. Ensure there is good fire hygiene. Inform management about faults and deficiencies and about the possibilities for arson.

D 16 INFO CARD for Suffocation, poisoning or drowning

In the WORM project, risk types such as these are described through 4 different situations where the risk of contact with hazardous atmosphere occurs. These include:

1. Work in a closed room
2. Work wearing a respirator
3. Work in/on/under water
4. Work above/in the proximity of water

These 4 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 6 generic safety barriers, namely questions of:

1. Protection of inhaled air
2. Monitoring of inhaled air
3. Personal protective devices
4. Equipment's state
5. User ability
6. First aid

Protection of inhaled air refers to, that there is protection against reduced oxygen concentration in the inhaled air e.g. from the presence of organic material or of inert gas, or protection against the presence of hazardous substances/poisonous gasses/vapour e.g. from work activities (solvents, combustion engines, welding), lack of cleaning, unwanted processes in materials (fertilizer, sludge, biomass, etc.) that can rot or degrade with the aid of heat or due to a lack of barricading of installation parts from rooms containing hazardous substances.

This is done e.g. by ensuring that there is respiratory supply before the room is entered and during work or for mechanical ventilation. Finally, it is about that the supplied respiratory air is in order, among others, it is suctioned from a location with clean air, is connected and secured correctly, that it is furnished in the correct mixture and amount, not too much or too little, e.g. due to incorrect settings on the device and about that there is not pollutants in the respiratory air, either from the pollution of valves or from earlier use.

Monitoring of inhaled air is about measuring the atmosphere prior to access and monitoring during the work by measuring oxygen and/or poisonous gasses/vapour.

Personal protective devices are about respiratory protection e.g. respiratory protective device and for work near/under water, having the right clothing and rescue equipment such as diving suits, survival suits, life vests or suitable swimwear.

Equipment's condition is about that equipment for air supply and the platform that is worked on is in order, cleaned and maintained. It is about the supply system for air is CE marked and maintained, that gas bottles are filled up and that valves and other equipment are in order, that the equipment is put together correctly that the right gas mixture is used, and that there is no contamination of the inhalation air.

It is also about the work platform and its ability to float, its securing at/against collision or being bumped into, loading of the platform with regard to weight distribution and overloading, if there are railings on the work platform, that surfaces do not slope against the water and are not slippery and that it is ensured objects cannot move, roll or swing close to the water. Finally, it is about persons on the floating object have the necessary experience especially in poor sight close to the water and in poor weather.

User ability is about being fit when using the respiratory protection and when working in water, also being able to swim and being able to tolerate stays in water and finally being aware of the hazards in relation to this.

With the use of a respiratory protective device it is about having good physical fitness when work is performed with respiratory air supply, attention to danger at extreme temperatures (under -10°C, over 30 °C) and attention to danger during heavy physical work.

When working in and near water it is about good physical condition in water, access to and the use of suitable swimwear that, among others, protects against the cold, good swimming ability and attention to surroundings in or close to the water, which can quickly lead to exhaustion. It is also about attention to danger during high waves or strong current and cold water, when there are cables, constructions, net or other objects in the water. Finally, it is about attention to danger when driving a car close to the water.

First aid is about the saving of people in the water and from closed rooms.

It is about the company's skeleton staff being in place and sufficiently prepared regarding accident situations that multiple employees can come into contact with each other during the work that promotes fast intervention when an error occurs. It is about there being sufficient control for people in the water, the presence of a rescue team when there are people in the water, which can offer first aid, of access to effective medical help (aids) which arrive quickly (within 15 minutes).

When working in closed rooms, it is also about good means of access to closed rooms in association with lifesaving and supervision with working in closed rooms.

MANAGEMENT

<p>Hazard: for suffocation, poisoning or drowning</p> <p>This includes work in closed rooms, work wearing a respiratory protective device, work in/on/under water or work above/in the proximity of water.</p>			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Protection of inhalation air	Investigate whether work in a closed room is necessary and whether there can be reduced oxygen content or hazardous substances present. Observe the need for ventilation and the supply of respiratory air before work is begun, during the work and cleaning up. Investigate whether the ventilation and respiratory air is in order, cleaned and well maintained.	Evaluate whether work in a closed room is necessary and whether there can be reduced oxygen content or hazardous substances present. Evaluate the need for ventilation and the supply of respiratory air before work is begun, during the work and cleaning up. Evaluate whether the ventilation and respiratory air is in order, cleaned and well maintained.	Ensure that work in closed rooms only occurs when it is necessary. Ensure there is sufficient ventilation and respiratory air. Ensure there are procedures for work, repairs and maintenance. Motivate and instruct employees in how they shall work in closed rooms and near/in water and what feedback they shall give for faults and deficiencies.
Monitoring of respiratory air	Investigate the atmosphere in the closed room and the respiratory air for oxygen content and for the content of hazardous substances when measuring before the work begins and while the work is being performed. Investigate limit values for safe atmosphere.	Evaluate the atmosphere in the closed room and the respiratory air for oxygen content and for the content of hazardous substances when measuring before the work begins and while the work is being performed.	Ensure that there is measuring equipment for monitoring of work and that it is calibrated and in order. Inform employees about the measurements and instruct them in how they shall act when there is a lack of measurements or limit values are exceeded.
Personal protective devices	Investigate which personal protective devices are necessary for the work and whether they are in order. Investigate whether employees know how they shall be used.	Evaluate which personal protective devices are necessary for the work and whether they are in order. Evaluate whether employees know how they shall be used.	Ensure there are the necessary personal protective devices. Ensure there are procedures for usage, repairs and maintenance. Train employees in the use.
Equipment's state	Observe the work platform and/or ventilation and respirator is in order cleaned and maintained. Observe the placement of the platform.	Evaluate whether the work platform and/or ventilation and respirator is in order cleaned and maintained. Evaluate the placement of the platform.	Ensure that the work platform is safely placed, that the platform, ventilation and respirator are in order and cleaned. Ensure there are procedures for usage, repairs and maintenance.
User ability	Observe whether employees are fit for the use of respiratory protection and for working in water. Investigate whether they can swim and tolerate stays in water.	Evaluate whether employees are fit for the use of respiratory protection and for working in water. Evaluate whether they can swim and tolerate stays in water.	Check employee's fitness in relation to the use of respiratory protection and for working in water. Train employees in swimming and stays in water.
First aid	Observe whether the company's preparedness is sufficient. Investigate whether there is the possibility for professional medical help to come quickly (within 15 min.)	Evaluate whether the company's preparedness is sufficient. Evaluate the possibility for professional medical help to come quickly (within 15 min.)	Ensure there are training, instruction and education for preparedness. Ensure there is an agreement for professional medical help (within 15 min.)

EMPLOYEE			
<p>Hazard: for suffocation, poisoning or drowning</p> <p>This includes work in closed rooms, work wearing a respiratory protective device, work in/on/under water or work above/in the proximity of water.</p>			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Protection of inhalation air	<p>Investigate whether work in a closed room is necessary and whether there can be reduced oxygen content or hazardous substances present.</p> <p>Observe the need for ventilation and the supply of respiratory air before work is begun, during the work and cleaning up.</p> <p>Investigate whether the ventilation and respiratory air is in order, cleaned and well maintained.</p>	<p>Evaluate whether work in a closed room is necessary and whether there can be reduced oxygen content or hazardous substances present.</p> <p>Evaluate the need for ventilation and the supply of respiratory air before work is begun, during the work and cleaning up.</p> <p>Evaluate whether the ventilation and respiratory air is in order, cleaned and well maintained.</p>	<p>Only work in closed rooms when necessary and ensure there is sufficient ventilation and respiratory air.</p> <p>Follow procedures for work and for repairs and maintenance.</p>
Monitoring of respiratory air	<p>Investigate the atmosphere in the closed room and the respiratory air for oxygen content and for the content of hazardous substances when measuring before the work begins and while the work is being performed.</p> <p>Investigate limit values for safe atmosphere.</p>	<p>Evaluate the atmosphere in the closed room and the respiratory air for oxygen content and for the content of hazardous substances when measuring before the work begins and while the work is being performed.</p>	<p>Use the results from measurements.</p> <p>Stop the work when there is a lack of measurements or if established limit values are exceeded.</p> <p>Inform colleagues and management about deficiencies and excesses.</p>
Personal protective devices	<p>Investigate which personal protective devices are necessary for the work.</p> <p>Investigate whether they are in order. Investigate whether you know how they shall be used.</p>	<p>Evaluate which personal protective devices are necessary for the work.</p> <p>Evaluate whether they are in order.</p> <p>Evaluate whether you know how they shall be used.</p>	<p>Use the necessary personal protective devices.</p> <p>Follow procedures for usage, repairs and maintenance.</p>
Equipment's state	<p>Observe whether the work platform and/or ventilation and respirator is in order, cleaned and maintained.</p> <p>Observe the placement of the platform.</p>	<p>Evaluate whether the work platform and/or ventilation and respirator is in order, cleaned and maintained.</p> <p>Evaluate the placement of the platform. Evaluate your experience in working near/in water.</p>	<p>Follow procedures for usage, repairs and maintenance.</p> <p>Inform colleagues and management in the event of errors and deficiencies.</p>
User ability	<p>Observe whether you are fit enough for the use of respiratory protection and work in water.</p> <p>Investigate whether you can swim and tolerate stays in water.</p> <p>Observe the dangers of the work.</p>	<p>Evaluate whether you are fit enough for the use of respiratory protection and for working in water.</p> <p>Evaluate whether you can swim and tolerate stays in water.</p> <p>Evaluate the dangers of the work.</p>	<p>Inform management if you are in doubt whether you are in a position to perform the work.</p>
First aid	<p>Investigate the company's preparedness in the case of explosions.</p>	<p>Evaluate the company's preparedness in the case of explosions.</p>	<p>Participate in education and training of preparedness.</p>

D 17 INFO CARD for Personal injury by explosion

In the WORM project, risk types such as these are described through 5 different situations where the risk of contact with hazardous chemicals occurs. These include:

1. Work near pressurized apparatus, containers or other items
2. Work near/with explosive vapour, gasses
3. Work near/with (fine) dust that can cause explosion
4. Work near/with solid explosives
5. Work near/with substances that can cause exothermic reactions

These 5 different risk types have different types of requirements and safety barriers, which there is legislation for or guidelines drafted for. In WORM analyses these risk types fundamentally contain 6 generic safety barriers, namely questions of:

1. Equipment and materials condition and placement
2. Process control and monitoring
3. Explosion protection
4. Personal protective devices
5. First aid
6. Behaviour

Equipment and materials condition and placement is about that equipment and materials are suited for the chemicals used, and that the equipment is placed in secure surroundings and is in order.

Equipment and materials condition refers to that a container is used which can resist pressure, temperature and the characteristics of the contents, and where the construction material is in a good condition, that the containers are correctly constructed and/or connected together, that explosives are packaged, transported and stored correctly. Also that equipment is arranged so that the spread of flammable dust to the room is avoided and it is avoided that dust in the room is spread.

Placement means that containers are located so they are protected against external sources of heat, such as hot work, external fires and the sun's heat, and against external influences such as collision and falling objects and that the base is stable.

Process control and monitoring is about having knowledge of the chemicals' hazardous properties and ensure that processes are planned and carried out so that the risk of explosion is avoided or reduced or, that a potential explosion-like reaction is controlled safely in relation to the equipment and that this is monitored, also to ensure good cleaning, order and tidiness.

Familiarity with the chemicals' properties refers to, among others, that employees know safety and workplace usage instructions, and that there is attention to danger when work is performed in buildings/systems where fine dust is found.

Process control refers to any increase in pressure is controlled, among others, by regulating the fill level to ensure that it is not filled incorrectly/too large a quantity of reagent, at temperature, pressure or fluid level in the receptacle is observed and controlled, and that it is ensured that there is always space for the fluid's expansion. Also that it is secured against undesirable/unconscious mixture of substances (separate storage and process), among others, to safeguard against undesired exothermic reactions.

By process control it is also meant that raw materials are controlled prior to use with regard to their specification (particle size, moisture, impurities, other) and solid substances and raw materials are secured against pollution that can lead to dust explosions, and finally that the production of solid substances is guaranteed the right quality and finally, that for work with solid explosives, ignition occurs at the correct point in time.

Good cleaning, order and tidiness refers to cleaning and keeping the system free, to rinse (containers, pipes, etc.) from flammable solid substances, to clean the workplace and remove flammable solid substances, to ensure effective cleaning, where explosive gasses/vapour can otherwise be formed and finally that systems that solely contain oxygen are not contaminated with flammable substances (such as grease and lubricants) when working with solid explosives.

Explosion protection is about ensuring against conditions occurring with the hazard of explosion, among others, by avoiding or limiting explosive atmospheres, to remove sources of ignition and finally to reduce consequences of a potential explosion.

By avoiding explosive atmospheres it is meant, among others, to secure suitable ventilation to remove explosive gasses, vapour and dust, and at the same time ensure that the ventilation, including natural ventilation, does not whirl up dust or to remove explosive atmosphere by adding a nitrogen cover and ensuring that the cover is intact.

By removal of sources of ignition, it refers to securing against ignition in an explosive atmosphere by avoiding contamination with metals, to ensure that electrical equipment and cables are in good condition, that mechanical equipment is in good condition, that heat sources in the proximity are insulated, that there is sufficient cooling of systems and foundations, that devices are earthed, that the transport speed of solid substances through pipes is passing slowly in order to avoid static electricity, to have good control over activities (such as welding, sanding) that cause flames and sparks, to avoid processes in substances that may cause self-heating.

Reducing consequences of explosions means to ensure there is pressure relief, among others, through the use of safety valves, relief hatches and doors.

Personal protective devices is about wearing personal protective devices, as protection against explosion effects when working, which can lead to explosion such as work near/with (fine) dust, solid explosives and substances that can cause exothermic reactions.

First aid is about the company's readiness sufficiently being prepared for accident situations, that the company's skeleton staff is in place, that multiple employees can come into contact with each other during the work, which promotes a fast intervention when faults occur and the presence of employees that can offer first aid, and that professional medical help arrives quickly (within 15 minutes).

Behaviour is about having the knowledge and being aware that there is a risk for conditions that can lead to explosions and by its behaviour contribute to preventing ignition and not increase the risks. It is about avoiding sources of ignition in surroundings where explosive atmosphere can occur, among others, by avoiding the unmotivated discharge of substances, to have secured, that one cannot cause ignition from e.g. static electricity by the open discharge of substances or in association with cleaning.

MANAGEMENT

<p>Hazard: for personal injury – hearing damage, damage to lungs, injury from being knocked down from shrapnel or being killed</p> <p>This includes when working near/by pressurized apparatuses, explosive vapours, gasses, (fine) dust that can cause explosion, solid explosives or substances that can cause exothermic reactions</p>			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Equipment and materials condition and placement	Observe whether equipment and materials are suited/approved for the used chemicals, Observe whether the equipment is placed in secure surroundings Observe whether the equipment and materials are in order.	Evaluate whether equipment and materials are suited/approved for the used chemicals, Evaluate whether the equipment is placed in secure surroundings Evaluate whether the equipment and materials are in order.	Ensure that equipment and materials are suitable. Ensure that the equipment is placed safely. Ensure there are procedures for the repair and maintenance of equipment.
Process control and monitoring	Investigate employee familiarity with the chemicals. Investigate whether processes can be carried out so the hazard for explosion is reduced or controlled safely in relation to the equipment. Observe whether processes are sufficiently monitored. Observe whether grounds and buildings are clean and tidy.	Evaluate employee familiarity with the chemicals. Evaluate whether processes can be carried out so the hazard for explosion is reduced or controlled safely in relation to the equipment. Evaluate whether processes are sufficiently monitored. Evaluate whether grounds and buildings are clean and tidy.	Instruct and train employees in work with chemicals and processes. Ensure there is sufficient monitoring of the processes. Ensure there are procedures for cleaning grounds and buildings. .
Safeguarding against explosion	Observe whether there are sufficient safeguards against explosion in the form of pressure relief and the removal of sources of ignition. Observe whether safety measures are sufficient to ensure against damage in the event of an explosion.	Evaluate whether there are sufficient safeguards against explosion in the form of pressure relief and the removal of sources of ignition. Evaluate whether safety measures are sufficient to ensure against damage in the event of an explosion.	Ensure there are sufficient safeguards against explosion in the form of pressure relief and the removal of sources of ignition. Ensure there are sufficient safety measures to ensure against damage in the event of an explosion. Ensure there are procedures for control, repair and maintenance of the safety measures.
Personal protective devices	Investigate the need for personal protective devices that protect against the effects of explosion. Observe employee use of personal protective devices.	Evaluate the need for personal protective devices that protect against the effects of explosion. Evaluate employee use of personal protective devices.	Ensure there are personal protective devices that protect against the effects of explosion. Ensure there is instruction, repairs and maintenance.
First aid	Observe whether the company's readiness is sufficient in the case of explosions. Investigate whether there is the possibility for professional medical help to come quickly (within 15 min.)	Evaluate whether the company's readiness is sufficient in the case of explosions. Evaluate the possibility for professional medical help to come quickly (within 15 min.)	Ensure that the company has sufficient readiness. Ensure there is training, instruction and education for preparedness. Ensure there is an agreement for professional medical help (within 15 min.)
Behaviour	Observe whether employees are aware of conditions that can lead to explosions and have a safe behaviour.	Evaluate whether employees are aware of conditions that can lead to explosions and have a safe behaviour.	Motivate and instruct employees in safe behaviour.

EMPLOYEE			
<p>Hazard: for personal injury – hearing damage, damage to lungs, injury from being knocked down from shrapnel or being killed</p> <p>This includes when working near/by pressurized apparatuses, explosive vapours, gasses, (fine) dust that can cause explosion, solid explosives or substances that can cause exothermic reactions</p>			
Barrier type	Observe/ investigate	Understand/interpret evaluate	Act/perform
Equipment and materials condition and placement	Observe whether equipment and materials are approved for the used chemicals, Observe whether the equipment and materials are in order.	Evaluate whether equipment and materials are approved for the used chemicals, Evaluate whether the equipment and materials are in order.	Follow procedures for the repair and maintenance of equipment. Inform management in cases of faults and deficiencies.
Process control and monitoring	Observe your knowledge of chemicals and processes. Observe whether processes are sufficiently monitored. Observe whether grounds and buildings are clean and tidy.	Evaluate your knowledge of chemicals and processes. Evaluate whether processes are sufficiently monitored. Evaluate whether grounds and buildings are clean and tidy.	Follow procedures for work with chemicals and processes. Take action on the monitoring of processes. Ensure the grounds and buildings are cleaned. Inform management about faults and deficiencies.
Safeguarding against explosion	Observe whether pressure-relieving devices are in order and sources of ignition are removed. Observe whether safety measures against damage in case of explosion are in order.	Evaluate whether pressure-relieving devices are in order and sources of ignition are removed. Evaluate whether safety measures against damage in case of explosion are in order.	Follow procedures for control, repair and maintenance of the safety measures.
Personal protective devices	Investigate the need for personal protective devices that protect against the effects of explosion.	Evaluate the need for personal protective devices that protect against the effects of explosion. .	Use the necessary personal protective devices that protect against the effects of explosion. Inform management about faults and deficiencies.
First aid	Investigate the company's preparedness in the case of explosions.	Evaluate the company's preparedness in the case of explosions.	Participate in education and training of preparedness. Follow procedures in case of explosion.
Behaviour	Observe conditions that can lead to explosions and have safe behaviour.	Evaluate conditions that can lead to explosions and have safe behaviour.	Exhibit safe behaviour.

Dan-WORM is an expression for the Danish version of WORM, which is a large Dutch project carried out during the period 2003-2008. WORM stands for Working group for Occupational Risk Model.

This report describes the result of the Dan-WORM project, where the goal has been to give Danish businesses the possibility to use the Dutch results, and to seek to simplify the rather complicated results in WORM in such a way that the knowledge and tools can be used in small and medium sized businesses.

The report contains a thorough introduction into the theory about accident prevention, a description of the Dutch WORM project, and what tools have been developed in the Dan-WORM project. The report presents suggestions for using the tools and preventative processes.

The Dan-WORM project is financed by the Danish Working Environment Research Fund and has also been included in the Centre for research in production, management and working environment in smaller businesses "DAVID", which the National Research Centre for Working Environment NFA has been responsible for.

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